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Forest Resource Value and Benefit Measurement: Some Cross-Cultural Perspectives

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Preface

These papers were prepared for a technical session on Measurement of Forest Resource Values and Benefits as part of the joint meeting of the Forest Landscape, Recreation, and Tourism Management Section (S6.01) and the Social and Economic Aspects of Forestry Section (S4.07) of the International Union of Forestry Research Organizations. The 2-week joint meeting and study tour was held in Greece and Israel in late September and early October of 1988.

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B. L. D.
G. L. P.

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B. L. Driver and George L. Peterson, compilers[1]

[1]*Rocky Mountain Forest and Range Experiment Station. Headquarters is in Fort Collins, in cooperation with Colorado State University.*

Contents

Identification, Measurement, and Valuation of Environmental Change

George L. Peterson and B. L. Driver[1]

Abstract.—Different decisions need different kinds of information. Qualitative analysis identifies the type of environmental change caused by a decision. Quantitative analysis defines parameters of change and measures of magnitude. Valuation measures strength of preference for those changes. "Value" has several different meanings, however, and valuation can be achieved in different ways. Economic valuation assigns monetary exchange prices, while other types of valuation use other approaches. This paper identifies and discusses these concepts and presents a model that identifies various components of the problem and demonstrates the definitions and measurements needed for different purposes.

Different Decisions Need Different Kinds of Value-Related Information

Environmental decisionmakers need information about the beneficial and detrimental consequences of alternative courses of action. The kind of information needed depends on the context and objectives of the decision. The goal is always to select the most valuable alternative, but the definition of "value" varies with context, and so does the method used to measure it.

For example, when asked to measure the "value" of a meal, an economist will simply state a sum of money, say $15.00. In answer to the same question, a nutritionist will describe the nutritional consequences of eating the meal. These answers demonstrate two different points of view. When the different

[1]*USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.*

purposes are made clear, it is obvious the two people are answering different questions. However, if either the economist or the nutritionist assumes the other is answering the same question, communication breaks down.

The Many Facets of "Value"

The word "value" has many different meanings. Artists sometimes use the word to describe color intensity or darkness. In mathematics, "value" means "magnitude," e.g., the "value" of pi is 3.1416. In ethical philosophy, "value" is tied to the concepts of right and wrong, good and bad, desirable and undesirable. To economists, the "value" of a thing is simply a sum of money. Because of the many concepts represented by the word, agreement on the definition of value is a prerequisite to the production of information for decisionmakers.

Morris (1956) differentiates operative value, conceived value, and object value. Operative value is the worth implied by the actual choices people make. Conceived value is the worth assigned by the choices people believe they ought to make. Object value is the worth implied by the choices of a perfectly informed decisionmaker whose choices and objectives are consistent.

Economic value is a special way to measure operative value in terms of monetary exchange. For people who are perfectly informed and whose choices are consistent with their objectives, there is no difference between the three definitions of economic value. In other words, for "economic man" there is no difference. In "actual man" the differences may be substantial (Simon 1985).

Santayana (1896) separates "aesthetic" and "moral" value. In his words, "morality has to do with the avoidance of evil and the pursuit of good; aesthetics only with enjoyment." A moral action is not desired for its own sake but only as an instrument to achievement of a higher good. For example, from the economic perspective, $100 worth of candy has the same value as $100 worth of education, because the candy can be sold for $100 and the money used to buy the education. Moral criteria suggest, however, that the long-term changes caused by education are of greater worth than the short-term pleasure given by candy.

The Economic Definition of Value

The economic definition of value is one of the most commonly used bases for valuation. It is a rigorous definition derived from a well developed framework of operational theory. Yet, it is often misunderstood and abused because the theory is complex, and good understanding requires specialized training. Economic value is also a familiar part of everyone's life, and confusion of familiarity with understanding is common.

Economic value is simply the amount of money (or the goods that could be purchased with the money) that one is willing to give up in order to get a thing or that one requires in compensation for the loss of a thing (Just et al. 1982, Randall 1984a). This sum of money is defined by the actual choices people make. Properly determining that sum of money, however, can be a formidable challenge. For reasons too involved to explain here, market prices are sometimes unacceptable or unavailable.

The economic value assigned to a good does not necessarily measure the value assigned to the objectives served by the good. As illustrated by the diamonds and water paradox, the value assigned to an objective may be great, while the economic value of a unit of the good that serves that objective is low because of an abundance of low priced substitutes. Thus, the function performed by drinking water is of great value, but the price of a glass of water will be zero given an abundance of free substitutes. Water is essential to life, but the specific glass of water in question will make no difference. The low price simply reflects the local context of supply and demand, not the importance of water in maintaining life. Compared with water, diamonds serve relatively trivial functions (as jewelry), but they are of great economic value because of short supply and high demand.

Welfare economics uses this definition of economic value to produce information for two social objectives: efficiency and equity. Efficiency asks whether a proposed change produces more economic value than it consumes, and whether it is better in that regard than competing changes. Equity questions the fairness of the distribution of gains and losses among people or regions. Two equally efficient actions may have different distributional consequences. They may also serve different ends for different people or for society as a whole and

may, therefore, have different values relative to objectives other than economic efficiency. Thus, efficiency information is important but not sufficient for public policy decisions (Randall 1984b).

Psychological Value

Valuation is a subjective human response to external stimuli. Psychologists also study value-related phenomena, including the description, explanation, and prediction of choices and preferences. In this sense, economics is a separate school of psychology, or perhaps those psychologists who study valuation behavior represent a separate school of economics, but the approach of psychologists to valuation behavior is different from that of economists.

Psychological theories and methods range from Freudian introspection to mathematical decision theory. Between these extremes are such topic areas as cognitive dissonance, attribution, social judgment, perception, motivation, and reasoned action. The theory of reasoned action (Ajzen and Fishbein 1980) illustrates one approach to psychological valuation.

The things psychologists have learned about attitudes and behaviors can help improve the validity of economic valuation. The theory of reasoned action demonstrates that measurement of economic value by hypothetical market methods (contingent valuation) requires correct identification of the valued object. When assigning economic value to a public good such as clean air, we must distinguish between (1) clean air, (2) policies that affect air quality, (3) beliefs about the efficacy of those policies, (4) beliefs about personal responsibility for air quality, and (5) a behavior such as payment for a policy said to affect air quality. A poorly framed contingent valuation question may lead different people to express attitudes toward different components of the question (Ajzen and Peterson 1988).

Other Anthropocentric Definitions of Value

Economists and psychologists study valuation from the point of view of individual behavior, but anthropocentrically justified values are not limited to those assigned directly by individual preferences. Sociologists and anthropologists also

study values, but from a social perspective (Cheek and Burch 1976, Kelly 1974). Other disciplines such as history, political science, art, music, and religion also study human values.

These social, ethical, and historical perspectives are important, because they help assure comprehensive understanding of the costs and benefits of environmental policies. In a complex society, it is often difficult for individuals to understand the social and long-term effects of their choices. Social science demonstrates the need for communal conscience, as with the "tragedy of the commons" (Hardin 1968), so that people can make more informed individual and institutional decisions.

Values Justified by Social Choice

Conflict between individual choices and social well-being is the basis for the "public interest" point of view often advocated by political ideologies or religious and philosophical maxims. The values thus advocated may be different from those motivating individual behavior. Public education, national defense, and preservation of wilderness areas are examples of products of social choice that imply public interest values. In such cases, social values are products of individual decisions to apply long-run constraints on short-run behavior. However, where social values have no sovereignty other than logical arguments, their inclusion in technical evaluation is a political act.

Intrinsic Value

The definitions of value discussed thus far are based on human preferences. Philosophers of environmental ethics define another approach under the rubric, "intrinsic value" (Callicott 1985; Rolston 1981, 1985). Unlike assignment of value by beliefs and preferences based on instrumental utility of an object in the satisfaction of human desires, intrinsic value is the product of belief that value is an intrinsic property of the object, independent of usefulness to humans.

Definitions of intrinsic value vary in content and stem from philosophical maxims and ethical beliefs. One proposition is that nonhuman entities have rights, and that their preferences assign values (Stone 1974). Another is that genetic information is intrinsically valuable ecological capital, because it is an im-

probable combination of the inherent and immutable properties of matter and energy, a product of eons of biological experimentation. Still another point of view is that humans, as moral agents with power to destroy or protect other species, have a duty to protect them. Intrinsic value is often associated with reverence for life.

On philosophical and ethical grounds, these arguments are difficult to refute, but within the political framework, they are effective only as justified by due process. From the economic point of view, intrinsic value has meaning when human beliefs or preferences assign it to nonhuman things. For example, economists have defined "existence value" as value assigned by human preference to the existence of things, independent of their instrumental services.

Definition, Measurement, and Valuation of Consequences

There are three basic ways to describe the consequences[2] of a given activity or change: qualitatively, quantitatively, and by valuation. Qualitative analysis simply identifies the changed conditions. Taking outdoor recreation as an example, jogging causes beneficial and detrimental changes in the condition of physical health. Qualitative analysis of the health benefits and costs of jogging identifies the kinds of changes that occur in the body. For example, jogging might cause a reduction in blood pressure, an improvement in aerobic capacity, or injury to bones or muscles. Complete qualitative analysis requires identification of all significantly affected variables on which human welfare depends.

Quantitative analysis measures the magnitude of change in each of the conditions of concern. Thus, while qualitative analysis of jogging identifies improved cardiovascular fitness as one of the changes, quantitative analysis uses numbers to describe the magnitude of a given change. Quantitative measurement requires definition of the affected variables in terms of measurable parameters and instruments or methods to measure changes in those parameters (Caws 1962, Stevens 1962).

[2] *By consequences, we mean the changes caused by an activity or action.*

Valuation measures the strength of the affective or preferential meanings associated with a change. According to Brown (1984), valuation measures the "assigned" values derived from an individual's "held" values.[3] We observe assigned values in the choices people make as they trade one action, condition, or thing for another. The economic (monetary) definition of assigned value is the amount of money one is willing to give up for (or requires in compensation for) the change in question. Giving up something of value is a cost, while receiving something of value is a benefit.

Thus, one's affective feelings toward the consequences of a choice identify the outcome as a benefit or cost. Prediction and measurement of the magnitude of change quantify the outcome. Valuation classifies it either as beneficial or detrimental and measures its relative importance to the decisionmaker's objectives. These two different types of information (i.e., quantitative measurement of changed conditions and valuation of those changes) are each useful in different decision contexts. For example, technical valuation is useful in benefit-cost analysis or economic impact assessment whereby decisionmakers attempt to describe the magnitude and distribution of monetary gains and losses caused by a proposed action. Qualitative and quantitative description of changed conditions is important to people who want to express and defend their preferences through political conflict resolution or market negotiation. In order to express and defend their preferences, people need to understand the consequences of alternative choices.

A Model of Costs and Benefits

Using recreation as an example, this section organizes the analysis of costs and benefits into a simple model. As shown in figure 1, people combine recreation opportunity and other things (such as travel, equipment, and skill) in a recreation production process (activity) by which they obtain desired consequences. Participation in the recreation activity causes

[3]Held values are the deeply seated and stable ethical and normative feelings or beliefs that tend to guide a person's choices. Morris' "conceived values" (1956) are of the "held value" type. Assigned values are the tradeoff prices defined by actual exchanges among alternative actions and things.

change in the person, environment, and society. The changes produced by the activity may vary with behavioral characteristics of the person (market segment).

Assuming the purpose of the analysis is economic valuation, it is possible to assign economic value to opportunities, attributes of opportunities, input factors, activities, or objectives. Consider a demand function specified for recreation opportunities. Finding that such a demand function can only predict the observed, Lancaster (1966) and Becker (1965) reformulated consumer demand theory in terms of characteristics of goods. Demand functions thus specified allow prediction of demand for new opportunities created by combining characteristics in innovative ways.

Following a suggestion by Hicks (1956), Morishima (1959) developed a theory of demand in terms of the objectives served by goods and their characteristics. Expression of demand functions in terms of the objectives of recreation activity allows economic valuation of those objectives. Economic value thus assigned is more useful than simple information about willingness to pay for recreation opportunities. It both measures economic value and also describes the reasons why people prefer one opportunity over another. However, in the normal economic approach, we assign economic value directly to the recreation opportunities. Assigning economic value to the consequences that pertain to specific objectives of participation in an opportunity is more complicated and does not necessarily lead to the same conclusion or serve the same purposes.

Information about economic efficiency does not satisfy the needs of all decisions. As with equity, some questions require

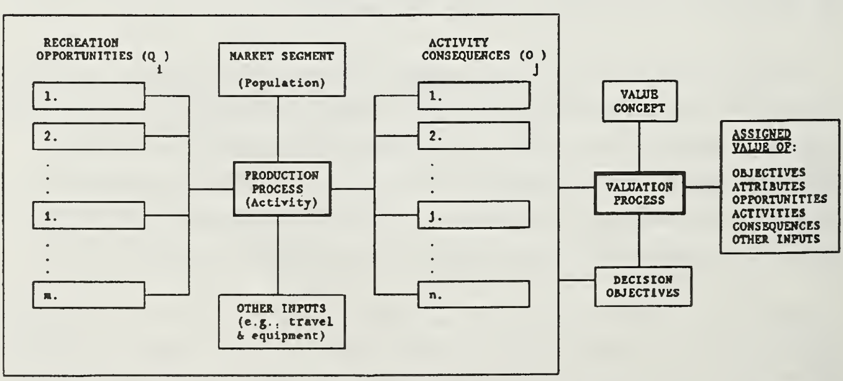

Figure 1.—A model of recreation costs and benefits.

exposure of specific changes. Different questions require different kinds of information. Thus, the "consequences" in figure 1 represent many different things. They may be perceived or actual changes in physical or mental health, environmental or social conditions, distribution of income, or recreation experience. The question to be answered determines how to specify the outcomes and how to assign value. For some questions, the answer may stop short of valuation.

We are now able to state the model mathematically, although full theoretical development transcends the scope of this paper. This simple mathematical statement is important, because it identifies the operational definitions needed before analysis can move from the domain of ideas to the domain of operations.

Define the following vectors:

Q = the set of recreation opportunities,

$= (q_1, q_2, \ldots, q_i, \ldots, q_m)$

A = the set of attributes of the opportunity,

$= (a_1, a_2, \ldots, a_k, \ldots, a_p)$

$S\pi$ = a set of personal characteristics describing market segment π,

$= (s_{\pi 1}, s_{\pi 2}, \ldots, s_{\pi h}, \ldots, s_{\pi z})$

$F\pi$ = the set of recreation activities by which consumers produce desired outcomes,

$= (f_{\pi 1}, f_{\pi 2}, \ldots, f_{\pi g}, \ldots, f_{\pi t})$

P = the set of other factor inputs that are combined with opportunities and attributes in activities,

$= (p_1, p_2, \ldots, p_r, \ldots, p_s)$

O = the set of important (benefit-related) variables o_j that change because of the recreation activity,

$= (o_1, o_2, \ldots, o_j, \ldots, o_n).$

Identification of the elements of Q, A, S, P, and O is the qualitative part of the analysis of benefits. Identification of the elements of O specifies those benefit-related variables expected to change because of the recreation activity. Definition of these variables in operational terms, so that quantitative measurement is possible, is the first step in quantitative analysis. It allows measurement of the magnitude of change.

The symbol $f_{\pi g}$ represents a process, not a magnitude. This process specifies the functional relationship for market segment π and activity g by which changes in Q, A, $S\pi$, and P cause changes in O, the vector of benefit-related variables. The model thus specified is

$$O = f_{\pi g}(Q, A, P, S\pi)$$

Given a change in an input variable, say A + C, the model predicts

$$0 + \delta = f_{\pi g}(Q, A + C, P\ S_{\pi},)$$

and

$$\delta = f_{\pi g}(Q, A + C, P, S_{\pi})$$

where

C = a vector of changes in the elements of A, and

δ = a vector of predicted changes in the benefit-related consequences.

Assume, for example, the recreation activity in question is river canoeing. One of the important characteristics of a given opportunity is the quantity of instream flow. Another important characteristic is water quality. Let the initial magnitudes of these two characteristics be a_1 and a_2, respectively. Assume a proposed change in water quality, from a_2 to $(a_2 + C_2)$. What quantitative changes in the benefit-related elements of O does the modification of water quality cause? At the initial condition of water quality, a_2, a river trip causes the state or condition of the participant to be the vector O. For the same river trip, a change in water quality from a_2 to $(a_2 + C_2)$ causes the jth element of O to change from o_j to $(o_j + \delta_j)$. The benefits (or losses) through river canoeing caused by the specified change in water quality is thus the vector δ describing the changes in each of the elements of O. Prediction of the magnitudes of

change (δ) in the elements of O completes the quantitative analysis of benefits (or losses). It does not, however, assign value to those changes. Quantitative analysis only states the magnitudes of change in those variables identified as important.

The above example describes the benefit-related consequences of a change in water quality. Another question is, what are the benefits of river canoeing? Here, the comparison of conditions is with versus without the float trip. To answer the question, first predict the vector O, assuming the trip does not occur. Then, predict O, given the trip does occur. The difference is the vector δ describing the benefit-related changes caused by the river trip. In this example, the recreation activity (river canoeing) has the magnitude "zero" in the first case and "one" in the second case.

Because the elements of O are benefit-related conditions, the vector δ describes the beneficial and detrimental changes in state caused by the change C. However, it is not a "valuation" model. It does not estimate the strength of preference for the change thus described. It simply states that the decision in question has caused a change of δ_j in the benefit-related condition o_j. Thus, in answer to the question, "what are the important consequences of C," we respond, "the important consequences of C are δ."

The next step is valuation, assignment of value (as opposed to magnitude) to the changes (δ) identified qualitatively and predicted and measured quantitatively. There are several ways to accomplish valuation, depending on the purpose of the information. One way is to measure affective, cognitive, and conative responses and infer attitudes and predict behavior, according to theories and methods of psychological value.

Another approach is to define some normative criterion of cost-effectiveness and rank alternative δ vectors by that criterion (deNeufville and Stafford 1971). Still another approach is economic efficiency, with value defined by willingness to pay or compensation demanded for changes in Q, A, P, F, or O, depending on the purpose of the information and availability of data. The underlying relationship is the production process F by which demand for O causes derived demand for Q, A, and P.

Measuring the economic value of the elements of Q does not require description of δ, the vector of changes in the bene-

fit-related consequences. However, description of the vector δ and measurement of the economic value of its elements assigns economic value to changes in Q , A, and P. Qualitative and quantitative description of δ is also useful in many decisions where economic information is not sufficient.

Summary and Conclusion

Good decisions require knowledge of the alternative courses of action and their consequences. However, different decisions may have different objectives and different specific information requirements. Much disagreement often occurs because different people are talking about different kinds of decisions.

Disagreement also arises from mixing different parts of the valuation problem. Decisionmakers are concerned about those variables that are important to the decision objectives and that differ in magnitude among the decision alternatives. Qualitative analysis *identifies* these variables. Quantitative analysis *measures the magnitudes* by which the decision alternatives change these salient variables. Valuation *measures strength of preference* for the decision alternatives, either by assigning value to the alternatives themselves or by assigning value to the variables that measure the changed conditions caused by the alternatives.

Valuation requires criteria by which to judge strength of preference. Many different value theories and valuation processes are available. Different systems are appropriate for different purposes and situations. Hidden disagreement about decision purposes and situations or about the value system being used leads to controversy. Are values to be assigned by political equilibrium, market equilibrium, descriptive analysis, or normative analysis? Is value justified by operative preferences, normative beliefs, or authoritative directives? Is the definition of value economic, psychologic, intrinsic, or something else? The objectives and context of the decision in question determine what is most appropriate.

The model presented in figure 1 embeds these questions in an organizing framework. Such a framework has two potential applications. It provides a paradigm by which to organize systematic thinking about a complex topic, and it offers potential for operational application to those problems where the vari-

ables can be identified and defined, where the magnitudes of change can be predicted and measured quantitatively, and where numeric valuation is needed and feasible.

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Effects of Forest Decline on Recreation and Tourism in Montane Forest Areas of Bavaria

Ulrike Pröbstl and Ulrich Ammer[1]

Abstract.—The reactions of recreationists to current forest decline were investigated in two forest highlands of Bavaria. Ways and means to mitigate the negative effects of forest decline on recreational values are discussed. Practical consequences for forestry were derived from the results.

Introduction

Forest decline is still on the increase. Although recent results (published in the 1987 Report on Forest Damage) show a slight lessening of adverse effects due to forest decline for conifers, the state of health of nonconiferous trees in still deteriorating.

While initially only the impact of forest decline on the availability of wood as a raw material, drinking water supply, and on protective measures against noise, avalanches, and erosion were taken into account, reports from various tourist areas in Germany state that the recreational function of forest is also being affected (Reutlinger 1985, Süddeutsche 1986).

The problem "Forest Decline and Recreation" is of concern and interest to not only forestry authorities and the tourist trade, but to all people who value forests as being important for their spiritual and physical well being.

The investigation results presented here are part of a research project (Pröbstl 1988) with special emphasis on the question of what public reactions will be to a further increase in the new kind of forest decline. This paper also deals with

[1]*Institute of Landscape Technics, Department of Forestry, University of Munich, FRG, Bavaria.*

the mainly forestry-oriented problem as to which measures can be taken to mitigate or halt a further deterioration in the state of our forests.

Method

Numerous investigations on landscape types (Nohl 1986) and recreational values (Loesch 1980) in the past decade have demonstrated that it is quite possible to determine the recreational quality of individual landscapes and forests. The present study, however, is based on the assumption that, due to the complexity of forest decline, starting with the psychological strain it imposes and ending with the lack of imagination as to the consequences, an enlarged methodological concept would be required, all the more so if results were to relate to future conditions. Figure 1 gives a summary of the methodical structure of this investigation.

In group discussions with potential recreationists, tourists in holiday resorts and local inhabitants, all of different age groups, an attempt was made to determine the basic opinions and anxieties about, as well as attitudes toward, forest decline. At the same time the main hypotheses for the projected interviews evolved from these discussions.

Observations, in turn, were based on the results of the interviews. The method series used here is characterized by the en-

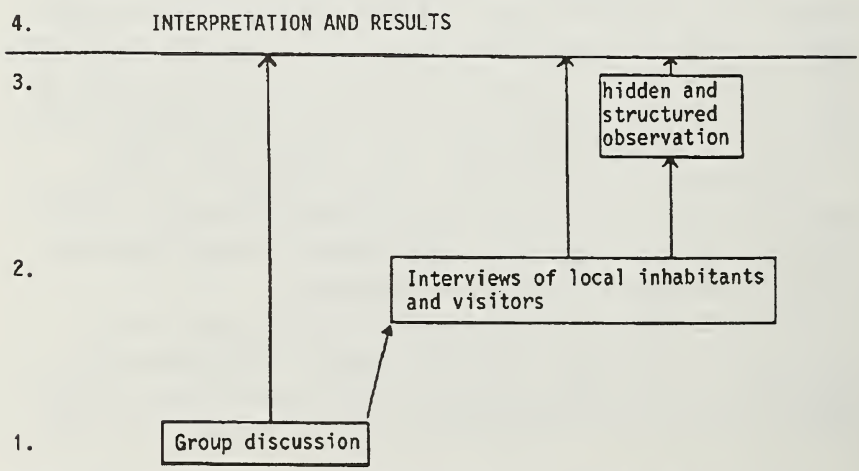

Figure 1.—Representation of methods used and their interrelationship.

deavor to relate opinions expressed in the interviews to observations of people's behavior. The forest areas chosen for this investigation were the Fichtelgebirge and the Bayerischer Wald, the preference for both of which as recreation areas is directly related to their dense forest cover. It is the forest which is the decisive factor as a recreation motive in these areas, in contrast to other areas such as the Bavarian Alps, Lake Constance, or the area between the rivers Rhine and Moselle (Kramer 1981).

A total of over 1,500 test persons participated in this investigation.

Results

Awareness of Forest Decline

> How do recreationists assess the present state of forests, is there an awareness of forest decline at all?

In the opinion of the majority of recreationists the extent of damage done to our forests as currently evidenced has not yet affected their recreational value. None of the 1,052 and 504 test person interviewed in the Bayerischer Wald and the Fichtelgebirge, respectively, gave forest decline as a possible cause for dissatisfaction with their holiday area. Table 1 shows, on the contrary, that 80% of the test persons will definitely or almost certainly return to either the Fichtelgebirge or the Bayerischer Wald for future holidays. Table 2 shows reasons why some people did not want to come back.

The above results could, however, undergo drastic changes if forest decline continues to increase. According to results from the assessment of various pictures by the test persons it is evident that forest visitors are fairly content with the current state but that a further deterioration in the state of health of our forests would have an adverse effect on recreational values and cause losses in tourists numbers. Considering the existing damage evident at higher altitudes of the Fichtelbebirge, in particular, the high degree of contentment with holiday resorts in that area comes as a surprise.

What explanation is there for the discrepancy between holiday contentment on the one hand and considerable forest damage on the other?

Observations and interviews brought to light (compare fig. 2) that for slightly affected stands (corresponding to damage class 1) only about 20% of the test persons were aware of the symptoms of forest decline.

At least every other visitor, i.e., about 60%, will recognize the effects of forest decline where greater detrimental effects are visible (predominance of damage classes 2 and 3) such as dead wood, small clearings, and rows of less dense or defoliated tree crowns.

All test persons will be aware that something is very wrong in stands where large portions have collapsed, with about 80% attributing this phenomenon to forest decline. About 20% will interpret this as being the result of windthrow or snowbreak, poor soil, or insect attack.

One of the reasons for the high contentment with recreation areas still experienced by most people probably lies in the layman's failing to identify the symptoms of forest decline.

In group discussions, in particular, and also during the observation it became evident that many recreationists turn a de-

Table 1.—Would you like to come back here?

Would you like to come back here?	Bayer. Wald *N = 1052*	Fichtelgebirge *N = 504*
certainly	42.4%	52.0%
almost certainly	32.1%	28.8%
undecided	23.2%	18.8%
probably not	1.7%	1.4%
under no circumstances	0.6%	—
CHI^2 15.12455 D.F. 4		SIGNIFICANCE 0.004

Table 2.—Would you like to come back here? If not, why not? (Several reasons may be given.)

Cause	Bayer. Wald *N = 1052*	Fichtelgebirge *N = 504*	Significance
too many people	0.2%	0.2%	n.s.
boredom	0.6%	1.0%	n.s.
weather	0.4%	0.8%	n.s.
change of scenery	1.4%	0.8%	n.s.
distance	0.7%	0.4%	n.s.

n.s. = not significant

liberately blind eye on changes for the worse in our forests. Understandably, a holiday (the best weeks of the year) should not be overcast by an awareness of environmental problems.

Thus, even in spontaneous perception of forests, people tend to more or less ignore individual negative impressions gained along longer stretches of forests such as dead trees, alone or in groups. The single disturbing factor is being neglected in favor of an overall positive impression.

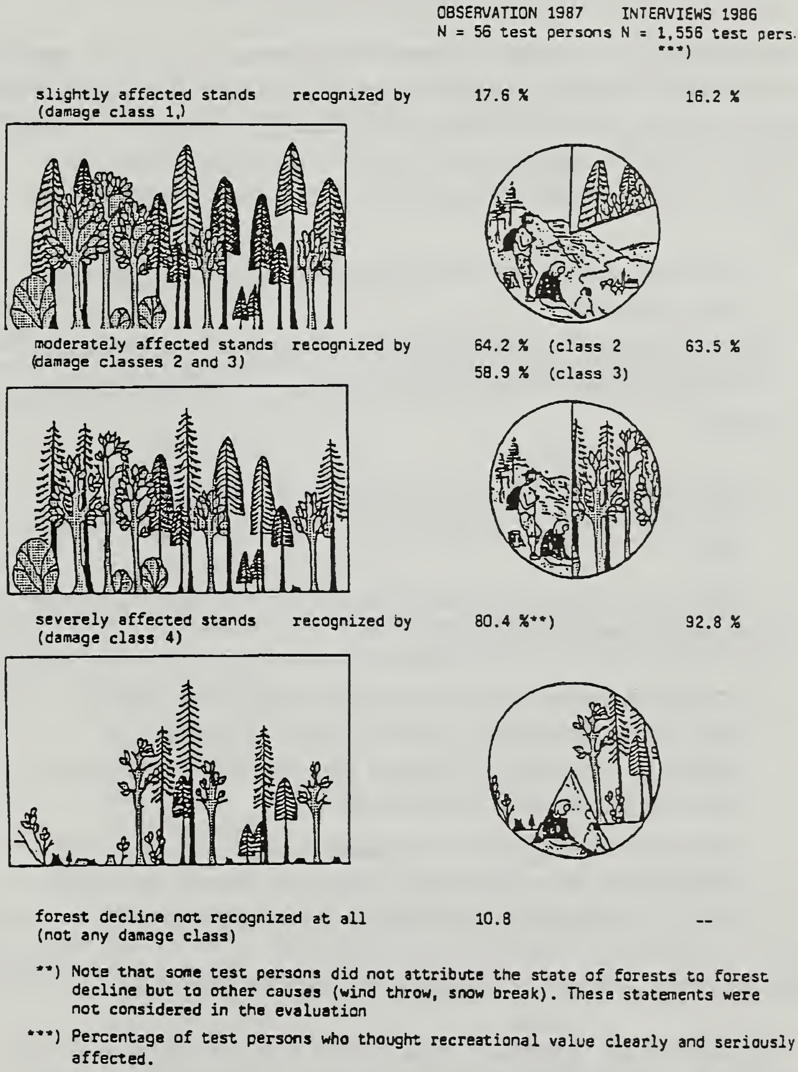

Figure 2.—Do recreationists recognize the symptoms of forest decline?

This attitude is probably due to the attempt to compensate for the appearance of damaged forests in recreation areas by comparison with potentially worse situations (e.g., town centers) or by pointing out other positive features within the same environment. In this context, reforestation plays an important part as a positive contrast to forest decline, as shown in the following quotation:

> Young seedlings are already growing up in the background, this conveys a positive feeling.

Generally, in all parts of the investigation, i.e., in group discussions, interviews, and observations, it became apparent that forest decline imposes a severe psychological strain on forest visitors. Hence compensation plays such an important role.

Three typical forms of argument crystallized from the survey:

1. An unshakable belief in the resistibility of nature is very common:

   (Quote): "All this talk about forest decline is only meant to make people afraid. Nature will not be defeated so easily."

2. Particularly in the 35- to 45-year age group attempts were often made to play down visible damage to forests:

   (Quote): "Perhaps some trees are ill, but they are still a long way from dying!"

3. A small percentage of forest visitors, particularly older generation test persons aged 55 years and above will generally dispute the fact that we are faced with an increasing forest decline.

   (Quote): "In the past there was no such word as forest decline, we used to say 'that tree won't last,' but today we have a word for much the same thing."

Mitigating Adverse Effects of Forest Decline

Apart from the question how forest visitors identified and assessed forest decline another question seemed of interest, especially with respect to a possible increase of forest decline:

Are there means, from a forestry point of view, to mitigate the adverse effects of forest decline on the recreational value of forests?

In the face of visible damage, in particular to old trees, forest visitors would time and again point to either the existence or the lack of regeneration measures. This realization is important, because it shows that the negative image of severely damaged forests could at least, in part, be reversed by immediate or timely reforestation.

Table 3.—Reforestation of small clearings making use of protection by remaining old trees to prevent large cleared areas from being formed caused by the death of trees (N = 1556).

very good solution	38.8%
good solution	35.1%
fair solution	17.4%
passable solution	4.9%
unsatisfactory, bad solution	3.8%

Table 4.—Reforestation of cleared areas with various tree species suited to site conditions which would develop more slowly into stable forests (N = 1556).

very good solution	41.0%
good solution	34.0%
fair solution	16.1%
passable solution	6.1%
unsatisfactory, bad solution	2.8%

Table 5.—Reforestation with maintenance of a few old, even injured, trees for greater variation of forest appearance despite large area regeneration (N = 1556).

very good solution	13.0%
good solution	34.3%
fair solution	29.8%
passable solution	14.2%
unsatisfactory, bad solution	8.7%

Table 6.—Reforestation of cleared areas with fast growing tree species, even not suited to site conditions, to create new forests as soon as possible (N = 1556).

very good solution	14.4%
good solution	16.7%
fair solution	18.3%
passable solution	17.4%
unsatisfactory, bad solution	33.2%

In order to gain an idea, beyond the mere fact of their necessity, which practical measures recreationists considered most suitable for regeneration and reforestation, various alternatives were offered for evaluation.

About 75% of the test persons considered the following a very good to good solution:

> Regeneration as soon as small clearings appear under the full protection of remaining old trees to avoid large cleared areas caused by the dying of old stands

and, if cleared areas already existed:

> Reforestation with various tree species suited to site conditions which would develop into stable forests, although more slowly.

A slightly less favorable score was given to reforestation while maintaining a few old, even injured, trees to achieve greater variety in the appearance of forests where large areas needed to be reforested.

The real surprise in this evaluation of reforestation suggestions was, however, the negative assessment of reforestation with fast growing tree species, even of species not suited to site conditions, for a quick production of new forest. A third (33.2%) of the test persons marked this solution as "unsatisfactory" or "bad" while another 17.4% marked it as merely "passable."

This implies that for most recreationists the suitability of tree species for a particular site, the ecological equilibrium, and the close association of old and young trees is considered very important.

In contrast, the time factor, i.e., the period until old forests have become firmly established, appears to be considered negligible, except perhaps by the group of forest visitors in the 56 years and above age group who are not willing or able to wait long enough and, therefore, prefer faster growing tree species.

In the event of a continuation and expansion of forest decline two other alternatives in lieu of reforestation are thought worth considering:

- forests could be left to themselves, as practiced in parts of the National Forest Reserve or in Natural Forest Reserves,

or

- forests could be converted into grassland after removal of root stocks and be used for other recreational purposes.

A large majority considered both suggestions either unsatisfactory or bad and advocated rejection.

In the opinion of recreationists, therefore, forest should remain forest. This is an important argument in favor of forestry and proof that forests remain indispensable, at least as far as the investigated areas are concerned.

For the majority of recreationists, i.e., for no less than 64.4%, landscapes are characterized by the presence of a certain tree species such as oak in the Spessart, spruce in the foothills of the Alps, and in the Fichtelgebirge. This association of tree species with an area is obviously very important. Hence this aspect, viz. the maintaining of a tree species or combination of tree species characteristic of an area, should at all costs be taken into consideration in reforestation planning.

Another means of making an impact on the appearance of a forest and its recreational value as seen by forest visitors lies in the cutting and removal of seriously injured or dead trees. Specific results were obtained in this context from the interviews in the Fichtelgebirge and the Bayerischer Wald. As table 9 demonstrates, test persons were shown pictures and asked to decide from which damage class upward individual trees or

Table 7.—Conversion of forest into meadows, removal of root stock and conversion of cleared site into grassland (N = 1556).

very good solution	38.8%
very good solution	3.8%
good solution	3.5%
fair solution	8.0%
passable solution	14.8%
unsatisfactory, bad solution	69.9%

Table 8.—Renunciation of tending measures or any kind of interference, forests are left to themselves even if clearings exist (N = 1556).

very good solution	4.6%
good solution	4.1%
fair solution	11.0%
passable solution	13.2%
unsatisfactory, bad solution	67.2%

groups of trees should be removed in order to maintain an appearance of the forest which would still attract recreationists.

As long as green needles were still clearly visible no necessity was seen to remove either individual trees or groups of trees. Nor did most people consider a removal necessary or absolutely necessary of individual trees or groups of trees which showed serious loss of needles but still looked green.

Dead trees should, in the opinion of all recreationists, be removed regardless of whether an individual tree or group of trees was concerned.

Finally, the effectivity of forest tending measures, specifically on the recreational value of slightly and moderately damaged forests, is represented in figure 3.

Figure 3 shows a simplified comparison of positive and negative observations about forests made by recreationists. The total sum of statements grouped as "positive aspects of

Table 9.—On the removal of trees belonging to different damage classes.

Single dead tree	N = 1556
Removal is:	
not necessary	20.8%
not urgent	29.0%
absolutely necessary	50.2%
A group of (up to 5) dead trees	N = 1556
Removal is:	
not necessary	10.4%
not urgent	20.7%
absolutely necessary	58.9%
Single tree with severe loss of needles, but still green	
Removal is:	N = 1556
not necessary	32.9%
not urgent	45.8%
absolutely necessary	21.3%
A group of up to 5 trees with severe loss of needles, but still green	
Removal is:	N = 1556
not necessary	19.7%
not urgent	45.3%
absolutely necessary	35.0%
Single tree with loss in density spreading from tree center to periphery	
Removal is:	N = 1556
not necessary	41.9%
not urgent	39.4%
absolutely necessary	18.7%

forest appearance" with regard to "forest tending measures" and "forest decline" vividly reflect the state of forests and the importance attributed to tending measures.

For slightly damaged forest stands total negative observations remained clearly below observed positive aspects. Since forests give the expected overall impression, many observations deal with side aspects such as plants covering the forest floor. Even for moderately damaged stands the number of positive statements remains constant. At the same time, however, the number of observations pointing out damaged trees, dead branches, and severe loss of needles has nearly doubled.

At this stage, the extent of tending measures is the crucial factor as to whether a generally positive or generally negative impression prevails. For severely damaged stands, total criticizing statements about forest tending exceed those on positive aspects in the forest, the latter being even at this stage still apparent. In the same measure as forests lost attractiveness due to forest decline, the remaining positive aspects (e.g., floor covering plants) tended to become less important.

Hence, emphasis should be placed on the fact that for moderately damaged forests in particular, forest tending measures are the crucial factor dominating recreational values and the way in which recreationists experience forests. If consideration is to be given to recreationist wishes, high tending costs will

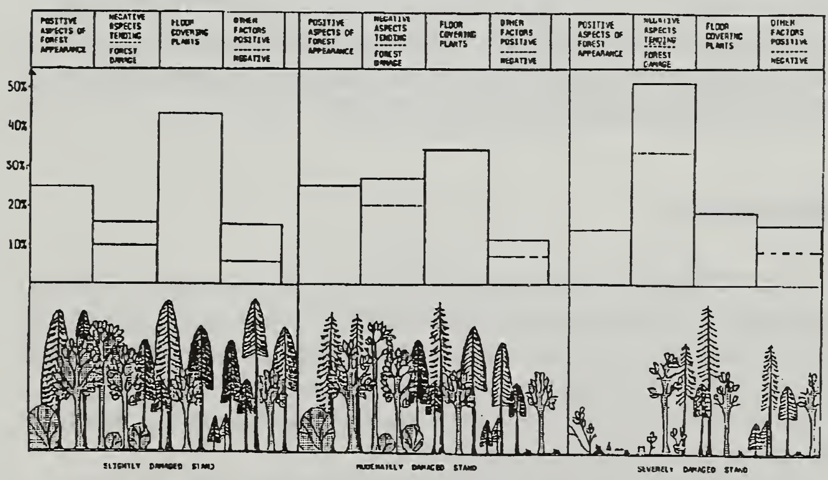

Figure 3.—Percentage of statements on different aspects in relation to extent of forest damage.

be required to maintain an attractive appearance of forests especially for an extensive conversion of moderately damaged forest stands into areas suitable for recreation. As reported above, a policy of forest tending can only be successfully practiced in the long run if forest decline spreads slowly and the collapse of entire areas can be held at bay.

Practical Consequences

An urgent appeal to forestry evolves from this study: forests should remain forests. In pursuit of this aim, stands in the process of dying as a consequence of forest decline should be reforested with tree species suitable to respective site conditions, making use of the protection of still existing adult trees. Alternatively, large scale reforestation should be introduced and pursued with every means at our disposal.

Even if large clearings cannot be avoided, reforestation with fast growing tree species is not favored by the majority of recreationists. Reforestation should aim at forests with a choice of species suitable to the specific conditions of individual sites.

Most forest visitors do not consider natural forests ideal for recreation. Intensive forest tending measures are, therefore, emphatically being welcomed. Dead or severely damaged trees should be removed wherever possible.

The results of the present investigation suggest that the negative aspects of slightly and moderately damaged forest stands can be, at least partly, mitigated by intensive forest tending measures such as stand tending, underplanting, or reforestation and removal of deadwood.

Summary

Three different methods of empirical social research (group discussion, interviews, and observation) were applied to gain an insight into the reactions of recreationists to current forest decline. The investigation was carried out in the forest highlands of the Fichtelgebirge and the Bayerischer Wald, both areas greatly dependent on tourism.

The results show that the recreationists are gravely concerned by the effects of forest decline. However, the present

extent of forest decline has not yet led to serious effects on the recreational value of forests as experienced by forest visitors.

Moreover, ways and means were closely investigated which, in the opinion of recreationists, could mitigate the negative effects of forest decline on recreational values.

Practical consequences for forestry were derived from the results of this investigation.

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Forest Decline in Norway: Valuation of Impacts on Environmental Goods

Ståle Navrud[1]

Abstract.—Dramatic forest decline due to air pollution is not expected in Norway. However, episodic high ozone concentrations and soil acidification may result in perceptible forest damages within 25-30 years, if the current level of air pollution/acid deposition sustains. An assessment model for valuation of the potential impacts on forest-related environmental goods is described. Some results from an empirical study using this model to estimate the social benefits from increased Norwegian fish stocks due to reduced acid depositions are also presented.

Valuing Environmental Goods—State of the Art in Norway

Environmental goods (and public goods in general), in opposition to private goods, are *not both* rival and nonexcludable. Thus, environmental goods are not bought and sold in markets, and have no real market prices. To include these values in cost-benefit analysis (CBA), and the decisionmaking process in general, several methods for valuation of such nonmarket goods have been developed over the past 20-25 years. For updated reviews of the different methods, their limitations and theoretical foundations, see Hoehn and Kreiger (1988), Johansson (1987), Navrud (1988a).

The two most popular methods for evaluation of public goods are:

1. Travel Cost Method (TCM);

2. Contingent Valuation Method (CVM).

[1] *Department of Forest Economics, Agricultural University of Norway, Ås, Norway.*

Both methods are based on the affected individual's willingness-to-pay (WTP) for the public good or a marginal change in the quality/quantity of the good.

TCM is an indirect method, in the sense that it is based on the idea that a certain private good (here, the cost of traveling to the forest area) is complementary to the public good in question, and that the observed demand for the private good can be used to estimate the value of the nonmarket, public good. CVM is a direct method where you try to construct a hypothetical market for the public good through interview techniques.

Another important difference between the two methods is that TCM only calculates the recreational value (use value) of the public good, while the CVM has the potential of getting the total WTP for all the affected individuals. That is, CVM estimates not only the use value, but also the nonuse values. In situations with a large degree of uncertainty about the effects, which characterizes the possibility of forest decline in Norway, one should expect large nonuse values motivated by risk-averted behavior.

The accuracy of these methods is, in most cases, sufficient to give an approximate size of the value of public goods. In cases where decisionmakers have no idea as to the economic value of preserving environmental quality, such information could be of great help in making the "right" decisions, and avoid (irreversible) decisions that reduce future management options.

In Norway the first empirical valuation study of environmental goods was carried out in 1980-1981. Strand (1981a) used a CVM to estimate the Norwegian population's total willingness-to-pay for preserving all freshwater fish stocks from extinction. The majority of the other Norwegian empirical valuation studies have also focused on this environmental good (using TCM and/or CVM) (Amundsen 1987; Carlsen 1987; Navrud 1984, 1988b, 1989a; Sandvik and Försund 1988; Scancke 1984; Strand 1981b; Ullberg 1988). In addition Hylland and Strand (1983) and Navrud (1988c) carried out CV studies on changes in local air quality levels, Strand (1985) did a CV study on social benefits from reduced automobile emissions, Hem (1986) and Aarskog (1988) used the CVM to evaluate water quality changes, Hervik et al. (1987) carried out a CV study on the preservation of rivers from hydroelectric development, Dahle et al. (1987) used the CVM to estimate the value

of preserving the three large carnivores in Norway (brown bear, wolverine, and wolf), and finally Södal (1988) used CVM to value moose hunting. See also Navrud (1989b) for an updated review of the Norwegian benefit estimation studies, and how they have been used in environmental decision making.

No Norwegian study has focused especially on forest-related environmental goods. However, the possibility of dramatic forest decline due to air pollution in the Nordic countries has resulted in plans for both a Norwegian (Norwegian Ministry of Environment (NME) 1988) and a Nordic research project (Navrud 1988a) on valuation of possible impacts on forest-related environmental goods from air pollution/acid rain.

Economic valuation of environmental goods has gained increased popularity among the national environmental protection authorities over the last few years. Today the Norwegian Ministry of Environment, the State Pollution Control Authority, and the Directorate of Nature Management all consider such studies to be an important tool in environmental protection and management decision. However, politicians and decisionmakers in other ministries and sectors of the society who also make managerial decisions that affect environmental goods have very little information about the valuation studies. Compared to the United States, Norway (and the other Nordic countries) have carried out very few such valuation studies, and also very few "complete" CBA's of projects with environmental impacts. The largest restriction in this area in Norway now seems to be the lack of scientists to carry out these analyses rather than the political will to undertake such projects. But, still there is a great need for information to decisionmakers on all levels of environmental management (community, country, and national) about how useful the methods for valuation of public goods can be in resource allocation, planning, and managerial decisions.

Definition of Forest-Related Environmental Goods

The forest-related environmental goods can be considered as public goods in the sense that, in most cases, consumption by one individual does not prevent consumption by another individual (nonrivalry), and in the sense that some of these goods

are nonexcludable in Norway. The Open-Air Recreation Act of June 28, 1957, states that all persons are entitled to free passage on foot, horse riding, sledding, bicycling, or the like (motorized traffic not included) on uncultivated land all year around, when this is done considerately and with due care.

The social benefits of forest-related environmental goods can be divided into use (recreational) and nonuse benefits:

- The use values result from recreation opportunities like hiking, fishing, hunting, observation/photography of wildlife, and nature/wilderness experience in general. The demand for and value of these recreation activities are very much dependent upon the scenic beauty of forests, especially "near-view" scenes that focus on physical forest characteristics, but also "far-view" scenes (Brown and Daniels 1986, Walsh and Olienyk 1981).

- The nonuse values can be divided into option and existence/bequest values. Option value is the value people place on keeping the option to undertake recreational activities in the future, although they do not do it now or are planning to do it. Existence value is the value people place on the existence of the forests without physically using it. This includes the aesthetic value of forest as an important element in the landscape, the cultural and symbolic value of the forest, and the value of the forest as a crucial part of our terrestrial ecosystem and as a large genetical reservoir. The value to today's people of delivering this existence to future generations is termed the bequest value.

Valuation of Impacts on Forest-Related Environmental Goods Due to Air Pollution

An expert panel describes the forest damage situation in Norway as follows (NME 1988):

> Based upon present knowledge, the current levels of ozone and downfall of acid components will result in perceptible damages to Norwegian forests in 25-30 years.

Thus, episodic high ozone concentrations (along the southeastern coast) and soil acidification (in Southern Norway) are considered the two most plausible hypothesis in the air pollution/forest decline debate in Norway. However, the dose-response relationships between air pollution and forest damage is still very unclear, and monitoring and research in this field is now intensified in Norway.

In anticipation of more information about the dose-response relationships, it is important to do economic analysis of possible future effects and develop a decision framework that continually can make use of new information to reach the best decisions based on the available information. EPRI (1982, 1983) and ERC (1982) describe decision analytic benefit-cost frameworks and decision tree models for changes in acid depositions. The major benefit from this approach is that it highlights the nature of choices at hand. The issue is not simply additional action versus no additional action, but how much, what kind, and when.

The information needed for a decision analysis of air pollution impacts on forestry and forest-related environmental goods includes:

1. *Dose-response functions* to predict the biological damage to forests caused by air pollutants. There are three methods of establishing dose-response functions:

   a. empirical models derived from field studies;

   b. process simulation models;

   c. survey of expert scientific opinion or expert panels.

De Steiguer and Pye (1988) argue that the urgent nature of many assessment efforts makes scientific judgment (i.e., model c) the only reasonable approach, and that there is increased acceptance of scientific opinion as a basis for air pollution risk assessments.

2. *Economic models* for valuing the social costs of these biological damages:

   a. economic models for impacts on forestry;

   b. economic models for impacts on forest-related environmental goods.

Although there are problems and uncertainties regarding the assessment of social costs from biological damages (especially the impacts on forest-related environmental goods), the most troublesome issue is the lack of credible dose-response functions. Thus, most of the current air pollution/forest research in Norway is in this field. However, there is a great need for this research to be directed toward developing dose-response functions that can be used in economic models. In this situation it is important that the economists develop economic models, and present to the natural scientist their needs concerning dose-response functions to make the economic models work. This demands interdisciplinary cooperation between natural and social scientists.

For valuation of impacts on forest-related environmental goods the following assessment model is suggested (Navrud 1988a):

1. Possible consequences of different hypotheses for forest decline, the probability of the hypotheses to be verified, and the time perspective of the damages are described on the basis of expert scientific opinion.

   These results can be presented as a probability distribution for different degrees of forest damage (e.g., measured as percentage of damaged trees per square unit in the affected area and the size of the total affected area).

2. This probability distribution is presented to representative samples of the Norwegian population in Contingent Valuation surveys to find the social benefits of avoiding environmental impacts from forest decline.

For the respondents to conceive the effects of different degrees of forest damage, it is important to visualize these effect. This can be done with help of drawings (manual or computerized), paintings, or photographs/slides. Another interesting possibility is video presentations, using enhanced computer graphic techniques to construct "live" scenarios. In the United States, there has been some success using this tool in preparation of Environmental Impact Statements (EIS) (Mills and Diamond 1988).

Construction of both questions and illustrations in these CV surveys can be greatly improved by close cooperation between natural scientists, economists, and psychologists (and professional video tape makers). In addition it is important to carry out controlled laboratory experiments to investigate people's perception of risk, and take these results into account when constructing the CV surveys. (Results from McClelland et. al. (1986) suggest that people overestimate their WTP for impacts, which have a probability of occurrence of less than 0.2.)

Both national and regional CV surveys (in the potentially most heavily affected areas) should be carried out. To test the accuracy of the use values found in these surveys, they should be compared to estimates from local TC surveys in threatened areas in southern Norway. To conduct such comparisons the CV surveys should collect data on:

1. The respondent's *information* level and *attitude* toward forest decline due to air pollution/acid rain, and how he/she perceives the described marginal changes in the quality/quantity of forest-related environmental goods (and the probabilities connected to different scenarios).

2. The respondent's *intended behavioral changes* due to this environmental change.

3. The respondent's *willingness-to-pay* to avoid the described forest damages.

In this way the respondents are also motivated to think thoroughly over their attitudes and intended behavior before stating their willingness-to-pay for commodities they are not used to paying for. This method establishes a valuable learning process for the respondents and is based on social psychology (see also Bishop and Heberlein 1984). In this way the degree of consistency between attitude, intended behavior, and value statements can be observed. Such CV surveys with both an internal and external (TC surveys) consistency check can increase the accuracy of the value estimates.

This relatively simple assessment model can be made more complex to produce more accurate estimates as new information on the dose-response functions becomes available. However, in the present state of incomplete information and large

uncertainties, a more detailed analysis does not guarantee a more perfect assessment. Since it could take many years to come up with better dose-response functions, it is important to carry out an assessment analysis now.

The assessment model has already been used in valuing social benefits from increased freshwater fish populations in southern Norway due to reduced acid depositions (Navrud 1989a). Here, only the "expected" value, not the complete probability distribution, of environmental impacts was presented in the CVM. This was mainly due to the fact that we already have experienced a drastic decline in fish stocks in southern Norway and also have considerably more information about this dose-response relationship than the one between air pollution/acidification and forest ecosystems.

Navrud (1989a) describes the results from a nationwide CV study of 2,032 persons (above 15 years of age), each representing one household. In addition, a regional CV survey of 573 households in the most heavily affected area "Sörlandet" (i.e., the four southernmost counties Telemark, Aust-Agder, Vest-Agder, and Rogaland) and a case study (using both TCM and CVM) of the River Vikedalselv in the county of Rogaland (Navrud 1988c) was conducted.

From the national survey the annual social benefits of marginal increments in freshwater fish populations, due to a 30-70% reduction of European sulphur emissions, is estimated to be approximately 530 million 1988 NOK (or about 76 million U.S. dollars at the present exchange rate). This is the value of achieving reproducible brown trout stocks in 567-928 lakes (larger than 5 ha) in "Sörlandet" and recovering "some Atlantic salmon" or "reproducible salmon stocks" in the same area.

Only 12-37% of the total WTP (i.e., 64-196 million 1988 NOK) was due to increased recreational value. This result supports the previous assumption of large nonuse values in situations with uncertainty about future environmental impacts. In both the national and regional CV surveys, the respondents were also asked how many additional days they intended to fish annually after the described increment in the fish stocks came through. Multiplied with estimates of recreational value per angler day (RVA) in restored rivers and lakes in "Sörlandet," this provides a rough consistency check of the recreational value from increased fish stocks found in the CV surveys.

In the local case study of the River Vikedalselv, RVA was estimated at 113-164 1988 NOK (or about 16-23 U.S. dollars at the present exchange rate). The results from the TC and CV models were very consistent, and the RVA estimate agreed very much with previous Norwegian TC studies when differences in methodology and characteristics of the rivers were taken into account.

The quality and the RVA of the River Vikedalselv is assumed to be representative of all restored Atlantic salmon and sea trout rivers due to reduced acid depositions. The RVA in the brown trout lakes in "Sörlandet" is expected to be considerably lower. How much lower, we will have more information about when case studies of representative brown trout lakes, in the counties of Aust- and Vest-Agder, are completed in 1990.

In the national survey the respondents stated an average of 1.7 additional angler days per person due to increased fish stocks. For all the 3.3 million inhabitants above 15 in Norway, this comes to a total of 5.61 million angler days. Multiplied by an RVA of 11-25 1988 NOK this yields the same recreational value as deduced from the national CV survey. This is considerably lower than the RVA found in the River Vikedalselv, but the expected low RVA of the restored brown trout lakes can reduce the average RVA for all the restored water bodies to this level.[2] However, an average RVA of 11-25 NOK seems very low. Since the stated increase in angler days represents nearly a 50% increase from the current level (1.7 additional angler days compared to the current average of 3.5 angler days per person), I suspect the respondents overstate their intended increase in angler days. The stated numbers seem to reflect the additional angler days they *wished* to make, rather than what they actually would do when faced with real life time and money constraints. New surveys using this approach should, therefore, try to incorporate these restrictions in the wording of the question to gain more realistic answers.

The assessment model for the impacts on forest-related environmental goods from air pollution should be based upon

[2]Preliminary results from the national survey showed a total of 11.7 million angler days in 1985, i.e., about 3.5 angler days per Norwegian above 15. Only about 10% of these days the Norwegians were fishing for Atlantic salmon/sea trout. Even if reduced acid depositions doubles or triples the angler days for these species, the majority of the angler days would still be spent on fishing for other freshwater fish species, mainly brown trout. Thus, the RVA estimate for restored brown trout lakes has large influence on the average RVA of all the restored water bodies.

experiences from the above mentioned study and the results from a recent pilot study presenting different scenarios for air pollution, forestry, and the dose-response relationship between air pollution and forest ecosystems (NME 1988).

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Monetary and Nonmonetary Trade-Offs of Urban Forest Site Attributes in a Logit Model of Recreation Choice

Herbert W. Schroeder,[1] John F. Dwyer,[1] Jordan J. Louviere,[2] and Donald H. Anderson[3]

Abstract.—Users of Chicago area parks and forest preserves participated in a choice experiment in which they chose between pairs of hypothetical sites for recreational day trips. The hypothetical sites were described in terms of vegetation, terrain, water features, recreational facilities, types of users, maintenance, travel time from home, and entry fees. Levels of these attributes were combined using a fractional factorial design that allowed estimation of the effect of each attribute on park choices. Logit analysis identified several market segments with different preference patterns. The coefficients of park attributes in the logit utility functions were used to examine trade-offs among the various attributes, providing a comparison of the relative importance of each attribute. The inclusion of entry fees in the design allowed estimation of monetary values for the levels of each attribute. The assignment of monetary values was complicated, however, by the fact that some market segments preferred higher fees, perhaps because they assumed that such fees would reduce problem behaviors in the park.

Introduction

A person deciding where to go for a recreational excursion must make trade-offs. Recreation sites vary on many attributes, and few recreationists are lucky enough to find the site that is best with respect to all these attributes. For most people,

[1] *USDA Forest Service, North Central Forest Experiment Station, Chicago, Illinois.*
[2] *Department of Marketing, University of Alberta, Edmonton, Alberta, Canada.*
[3] *Department of Statistics, University of Wyoming, Laramie, Wyoming.*

achieving the best possible level on one attribute (e.g., scenic beauty) requires that they accept less desirable levels on other attributes (e.g., distance from home). To provide the best possible sets of opportunities for recreationists, planners and managers of recreation sites should know which attributes and features are the most important in this choice process, and how much people are willing to give up on one attribute in order to gain an improvement on another. Without this information, managers risk developing sites that will not be used or that will provide far less enjoyment than is possible.

Multinominal logit (MNL) choice models have been used to study the process by which people make choices of recreation sites (Lin et al. 1988, Louviere et al. 1986, Peterson et al. 1983, Peterson et al. 1985, Schroeder and Louviere 1986). This class of model assumes that each site has a utility which is a function of its attributes:

$$u(i) = b(0) + b(1)\,x(i,1) + b(2)\,x(i,2) + \ldots + b(m)\,x(i,m)$$

where

$u(i)$ = utility of site i;

$x(i,1), \ldots, x(i,m)$ = attribute levels for site i; and

$b(0), b(1), \ldots b(m)$ = coefficients to be estimated.

The probability of choosing a site from a set of available sites is related to its utility by the following equation:

$$p(i) = e^{u(i)}/(e^{u(0)} + e^{u(1)} + \ldots + e^{u(i)} + \ldots e^{u(n)})$$

where

$p(i)$ = probability of choosing site i from the set containing sites 1 through n;

$u(i)$ = utility of site i;

$u(0)$ = utility of choosing no site (i.e., of doing something else instead); and

$u(1), \ldots, u(n)$ = utilities of all sites in the choice set.

This model will predict how the choice probabilities for all the parks in the set will change when one park's attributes change or when parks are added to or removed from the set. The data for estimating the coefficients b(j) of the model may

be obtained from a survey of people's actual choices of real park visits, or from choices among hypothetical alternatives presented to them by the researcher. The second approach is particularly useful for examining trade-offs among the various attributes of recreation sites. The researcher can design sets of alternatives that allow statistical estimation of the independent effects of each attribute and/or interactions among attributes, and can include options that do not presently exist "on the ground."

This paper describes the results of a choice experiment involving park and forest users in the Chicago area. The MNL model derived from this experiment will be used to illustrate how trade-offs between different site attributes can be evaluated from this kind of analysis. In some cases this can lead to the assignment of dollar values to alternative levels of park attributes, although the basic method in no way requires that trade-offs be expressed in monetary terms.

Data Collection

A sample of respondents was randomly drawn from telephone directories for northwest Chicago and Cook County. This area was chosen for the study because of its proximity to a large number of parks and forest preserves. An initial letter described the purpose of the study, informing the respondents that they had been chosen at random to participate and would be contacted by telephone within 7-10 days. In the telephone survey, questions were asked about the respondents' park and forest preserve use patterns and several socio-demographic classifiers.

Those who agreed to participate further were mailed a "park game" consisting of 16 pairs of park descriptions. These were based on a set of 22 park and forest preserve attributes found to be important in earlier research on park choice (Louviere and Woodworth 1984, Louviere et al. 1986, Schroeder and Louviere 1986). Respondents were instructed to read each pair of park descriptions and to decide which one of the parks they would prefer for an outdoor excursion in the Chicago area. Respondents were then asked whether they would realistically prefer to go to the park they had chosen or to do some other outdoor activity instead.

A total of 525 individuals were contacted by phone: 176 refused to participate, and 47 were ineligible because they had not been to a park in the last 12 months. Virtually everyone who completed the phone survey agreed to do the choice experiment, and 210 usable response forms were returned. The completion rate was, therefore, 57.5% for the phone survey and 70% for the choice experiment.

Results

Multinominal logit regression analysis was used to develop statistical models that explain how choice probabilities varied as a function of the features of the parks. A fractional factorial design was used which allowed estimation of the main effects of all the park attributes independently of each other and of any unobserved but significant two-way interactions. These coefficients were used to estimate utility values for each level of each attribute. Tables 1 through 3 show the amount of change in utility between the first level and each other level on each attribute. The total utility for a site is found by adding up the utilities for the attribute levels that apply to that park over all of the attributes in tables 1 through 3.

In addition to calculating utilities for park sites, the choice task allowed calculation of the utility of not visiting any park, i.e., of doing whatever alternative activity the person would choose if he or she did not go to a park. The utility of the "do something else" option in this study was 1.125. By including this alternative in the choice set along with the available parks it is possible to calculate the probability that a person would choose not to visit any park in the set.

The utility values tell us which of the park attribute levels are the most important for influencing people's choices of recreation areas. The most extreme values of utility in tables 1 and 2 are for travel time of 75 minutes (-.912), heavy crowding (-1.148), vandalism (-.844), and litter/trash (-.722). The negative signs mean that increasing levels on these attributes are associated with a decrease in the likelihood of a person choosing the site. Entry fees and the presence of teenagers and young people also have moderately strong negative utilities. The strongest positive utilities are for bodies of water, woods, picnic areas, and bicycle trails.

Table 1.—Utility values for entry fee and time from logit analysis of the recreation choice experiment.

Change in fee from	to	Change in utility
$0	$1	-.272
$0	$2	-.434
$0	$3	-.486
Change in travel time from	**to**	**Change in utility**
15 min.	35 min.	-.228
15 min.	55 min.	-.532
15 min.	75 min.	-.912

Table 2.—Utility, dollar, and time values for levels of park attributes presented in the experiment.

Attribute	Value of change from level one		
	Utility	Dollars	Time
Vegetation			
1. Mowed grass, very few trees anywhere	—	—	—
2. Mowed grass, scattered trees, no woods	.056	.21	4.91
3. Mowed grass, scattered trees, some dense woods	.270	.99	22.76
4. Mostly wooded, some open grassy areas under trees	.370	1.60	29.34
Water			
1. No streams, rivers, ponds or lakes	—	—	
2. Small stream or small pond	.462	2.54	35.39
3. Large stream or river, a major feature	.390	1.73	30.66
4. Large natural or man-made lake, a major feature	.490	> 3	37.24
Terrain			
1. Mostly flat	—	—	
2. Rolling hills with some flat areas	.112	.41	9.82
Grass			
1. Grass needs mowing	—	—	
2. Grass recently mowed	.090	.33	7.89

(continued)

Table 2.—(continued)

Attribute	Value of change from level one		
	Utility	Dollars	Time
Maintenance			
1. Structures and facilities need repair	—	—	
2. Structures and facilities well maintained	.134	.49	11.75
Crowding			
1. Little traffic, very few people, many places for privacy/quiet	—	—	
2. Light traffic, some people, a few places for privacy and quiet	-.146	-.54	-12.81
3. Moderate traffic, people almost everywhere, little privacy, some noise	-.544	< -3	-40.63
4. Lots of traffic, very crowded, no privacy, quite noisy	-1.148	< -3	< -60
Age distribution			
1. Mostly families and older adults	—	—	
2. Mostly teenagers and young people	-.418	-1.90	-32.50
Ethnicity and race			
1. Mostly ethnically and racially like yourself	—	—	
2. Mostly ethnically and racially mixed	-.198	-.73	-17.37
Police, sheriff, or ranger patrols			
1. Few police patrols, rarely seen	—	—	
2. Regular police patrols, highly visible	-.002	-.01	-.18

From the utility values we can make inferences about how changes in one attribute could be offset by changes in another. For example, all other things being equal, a site with a bike trail and very few trees would have about the same utility as a mostly wooded site with no bike trail. An increase from no crowding to moderate crowding would be offset if the age dis-

tribution changed from mostly teens to mostly family and the maintenance changed from poor to good. A heavily crowded site with woods and no vandalism would have about the same utility as an uncrowded site with vandalism and no trees.

Two of the attributes, entry fee and travel time, represent variables that are essentially continuous in the real world. Each of these attributes was represented by four different levels in the choice experiment; $0, $1, $2, and $3 for entry fees and 15, 35, 55, and 75 minutes for travel time. Utility values for levels of entry fee and travel time that were not actually included in the experiment can be approximated by interpolating between the utility values for the levels that were included.

In tables 2 and 3, values of entry fee and travel time corresponding to the utility values of other attribute levels are given. They represent the amount of time or the size of entry fee that would offset the change of utility associated with a particular level of an attribute. For example, all other things being equal, we can infer that the average recreationist in this experiment would be willing to travel an additional 29 minutes or pay an entry fee of $1.60 to visit a site that is mostly wooded instead of visiting one with few trees. Extrapolations beyond the attribute levels used in the experiment are not appropriate, so dollar values greater than 3 and travel times greater than 60 minutes are not presented in tables 2 and 3.

The trade-off between travel time and entry fee is shown graphically in figure 1. From this graph we could conclude, for

Table 3.—Utility, dollar, and time values for features represented as present or absent in the choice experiment.

Feature	Value of feature when present		
	Utility	Dollars	Time
Bicycling trails	.360	1.54	28.68
Picnic areas and tables	.348	1.47	27.89
Picnic shelters	.296	1.15	24.47
Hiking trails	.220	.81	19.30
Children's playgrounds	.220	.81	19.30
Swimming pool	.205	.75	17.98
Rowboat or canoe rental launch site	.198	.73	17.37
Athletic fields	.150	.55	13.16
Fishing	.146	.54	12.81
Litter/trash	-.722	< -3	-50.00
Vandalism	-.844	< -3	-56.42

example, that the average respondent in this experiment would be willing to travel 49 minutes instead of 15 minutes (an additional 33 minutes) to avoid paying an entry fee of $2.00. Note that the trade-off between travel time and entry fee is nonlinear. As entry fees increase, the additional distance that people would travel to avoid paying the fee increases at a diminishing rate.

Discussion

In the logit formulation, utility is a mathematical abstraction which is used to account for observed choice behavior. Higher utility for an alternative implies a greater likelihood of choosing that alternative, and lower utility implies a lesser likelihood of choosing the alternative. Thus, this approach expresses trade-offs in terms of how changes in attributes affect choice probabilities. In the experiment discussed in this paper the trade-off analysis suggests that social use attributes (crowding, litter, vandalism) of Chicago area recreation sites are quite important relative to the natural features, facilities, and spe-

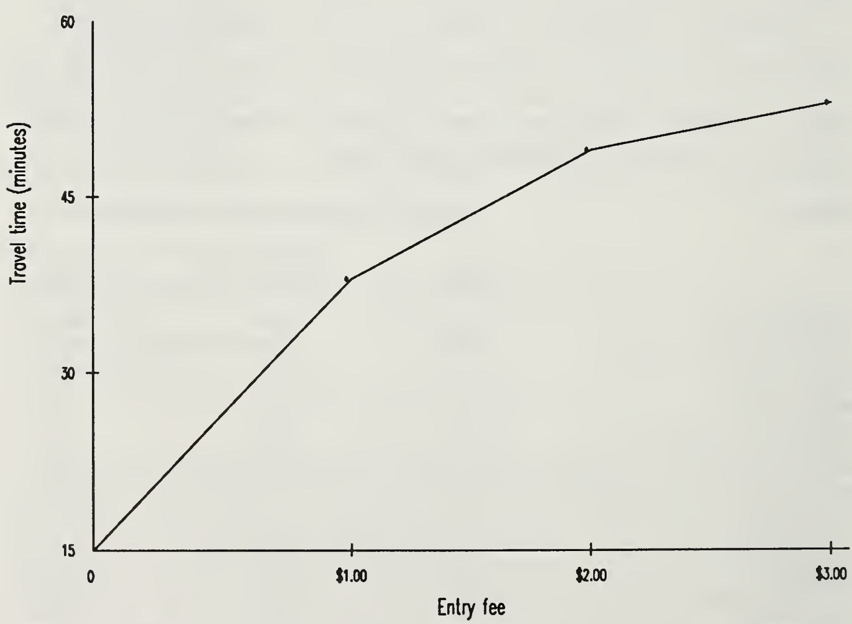

Figure 1.—Values of travel time and entry fee having equal utility.

cific activities available at a site. Water and vegetation are the most important natural features at these sites. Bicycle trails, picnic areas and tables, and picnic shelters are the most important recreation facilities.

The inclusion of inherently continuous variables (travel time and entry fee) in the experiment makes it possible to represent abstract utility values in terms of concrete behaviors. For example, we could infer from table 2 that an average respondent in this experiment would be willing to drive almost an hour longer to visit a site that is free from vandalism. Thus, a successful vandalism control program would be expected to greatly increase the market area that would be served by a park. These results can be used to predict the impact of a wide range of changes in site attributes on the market area for a site.

The inclusion of a payment vehicle, such as entry fee, in the experiment makes it possible to translate utility values into dollar equivalents. This provides an alternative to the usual contingent valuation and hedonic pricing approaches for estimating willingness to pay for changes in attributes of recreation sites. These dollar values must be interpreted carefully, however. Utility was not a linear function of entry fee in this study, so that the utility of a given change in fee depends on the starting point (i.e., the fee already in effect). For example, a change from $0 to $1 has more than five times the impact on utility than a change from $2 to $3.

Note that the dollar values presented (as well as utility and time) correspond to specific changes in particular attributes, assuming that everything else remains the same. Consequently, they are an indication of the additional amount that individuals are willing to pay (on average) for that specific change (i.e., $1.54 for bicycle trails). This estimate of the change in site value attributable to a change in site attributes is useful to guide the decision of whether to make that change. For example, is the cost of building a bicycle trail offset by the increased value of $1.54 per visitor? It is not appropriate to add the dollar values for each attribute to get a total site value since the relationship between dollars and utility is not linear. The utility of a site can, however, be obtained by adding the utility estimates for its attributes. The dollar value of the site might then be estimated by determining what increase in entry fee will reduce the site's utility until it equals the utility of doing something other than visiting a park.

The analysis presented here could be viewed as a somewhat unusual application of the contingent valuation method where considerable attention has been given to manipulation of site attributes. If the focus of the study had been primarily on estimating the willingness of users to pay for site attributes, then a wider range of fees might have been included.

The results of this study can be used to guide pricing policy because they show the average amounts that individuals are willing to pay to have particular attributes available to them. For example, assuming that fees are currently $0, individuals are willing to pay an average of $0.81 to have children's playgrounds and $0.75 for a swimming pool. However, it is likely that more useful information to guide pricing decisions can be generated by solving the logit choice model under various pricing levels and using the resulting changes in the probability of using the site to derive estimates of site use under alternate fees (i.e., site demand).

The results for all the attributes in tables 1 through 3 are based on the aggregate choice probabilities for the whole sample of respondents and do not necessarily reflect the preferences of any specific individual or segment. This level of analysis is appropriate if one is interested in the total response of the population to changes in park attributes. Segmentation of the population or a disaggregate analysis is required if more detailed information is desired about individual responses.

A problem in translating utility values into dollars appears, however, if we look at subgroups or segments of respondents having similar socioeconomic characteristics and park use patterns. For this experiment five such "market segments" were identified by means of cluster analysis, each with its own distinct pattern of utilities for the various park attributes. Three of these segments, involving about one-fourth of the sample, had either a nonmonotonic or an increasing relationship between entry fee and utility. In other words, for these segments the highest entry fee was preferred to at least one of the lower levels of fee. Perhaps the respondents in these segments were assuming that higher entry fees would reduce crowding and exclude certain kinds of problem users from the site, or that the fees would be used to improve maintenance and facilities. In any event, the nature of their response to the levels of entry fee included in this study prevents us from inferring dollar values for these segments. The inclusion of these individuals in

the total sample tends to suppress the dollar values for park attributes.

This example of a park choice experiment shows that useful information about trade-offs among park attributes can be obtained from logit analysis of behavioral choice data for simulated park alternatives. The analytical tools for designing and analyzing such experiments are advancing rapidly, and they promise to be an increasingly important source of knowledge about how people choose parks and how to manage them. This information can provide very useful guides to park design and fee structures.

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Timber Harvest Aesthetics in Oak-Hickory: Does Forester Assistance Improve Scenic Beauty?

Dr. John Burde[1]

Abstract.—When a landowner decides to harvest timber, a concern may be the aesthetics of the residual stand. Timber sales assisted by a professional forester may result in a more scenic residual stand than those sales where no professional is involved. To test this hypothesis, the Scenic Beauty Estimation Method was used in Illinois to compare assisted sales with nonassisted sales in the oak-hickory type. Both summer and winter aesthetics were considered. Forester-assisted sales were considered more scenic in summer scenes. There was no difference in winter scenes. Viewers preferred the scenic beauty of summer scenes as compared to winter. The visibility of slash in winter is likely a major factor.

Introduction

The end of World War II brought many changes to American society. Demands for lumber products for new housing for the postwar baby boom were matched by increasing use of our nation's woodlands for recreation. Increased leisure time, combined with more readily available means of transportation, resulted in an increased public presence in the woods.

As a result, more of the public came in contact with timber harvests, forcing foresters to consider more closely the aesthetic impacts of logging. The conflict concerning timber harvest intensified during the 1970's and 1980's as a more environmentally aware population responded negatively to what they believed to be an ecologically unsound practice.

As a result, in the early 1970's, foresters began to pay closer attention to the aesthetics of timber harvest. This attention was manifested as a consideration for aesthetics in forest plan-

[1]*Department of Forestry, Southern Illinois University, Carbondale, Illinois.*

ning in both the public and private sectors, as well as additional efforts in research on the aesthetics of timber harvest. Most of the early research in forest aesthetics was conducted in the western United States.

The results reported here seek to assess how people perceive the aesthetics of timber harvest activities in Illinois. Specifically, a comparison will be made between timber harvests marked and assisted by staff foresters of the Illinois Division of Forestry and those conducted by the landowner or some other nonprofessional operator. In addition, the effect of seasonality will be addressed.

Methodology

Foresters have long sought a methodology to determine how the public perceives the affects of timber harvest on aesthetics. The earliest work in the field came from landscape architects. Such research generally sought to analyze a site based on line, texture, contrast, and color. Later studies combined the landscape parameters with testing developed in psychology literature. One such methodology widely used today is the Scenic Beauty Estimation (SBE) method, developed by the Rocky Mountain Forest and Range Experiment Station of the USDA Forest Service. The SBE method, created by Dr. Terry C. Daniel, Professor of Psychology at the University of Arizona, and Ron S. Boster, USDA Forest Service, was first used to test the aesthetics of ponderosa pine management in the Southwest. The methodology has subsequently been used throughout the country. The methodology is described in detail, along with a discussion of reliability and validity testing of the model, in "Measuring Landscape Esthetics: The Scenic Beauty Estimation Method" (Daniel and Boster 1976). The SBE method was utilized to assess the aesthetics of timber harvest in southern Illinois. Following is a brief description of the model and the procedures utilized to complete the study.

The SBE Model

The SBE method is based on the assumption that forest stand conditions can be expressed in photographs. Previous research supports this view (Moeller et al. 1974, Shafer and

Mietz 1970, Shafer and Richards 1974). Viewers then rate the forest scenes as to scenic beauty based on a personal scale. The methodology has been shown to be consistent, reliable, and valid.

The SBE method involved two phases: appropriate representation of the stand conditions in photographs, and assessment of those representations by viewers. Stands must be spatially defined prior to the onset of the analysis.

Photography

The photographs used in SBE are taken horizontally at random within the defined stand. Randomness is assured by using a random beginning point within the stand, followed by new sample points obtained by using randomly selected pacing distances in randomly selected directions. Focal length, film type, and camera type are consistent throughout the study. The end result is a series of photographs that depict the intensity of timber harvest, the conditions of the residual stand, and any remaining slash or damage. Some views, however, must be discarded if they are of poor photographic quality—overexposed, underexposed or blurred.

Six harvest sites were utilized for this study, three harvest operations assisted by the Illinois Division of Forestry and three operations not assisted, harvested by logger's choice. The specific sites were selected so as to minimize variation in residual basal area. Study sites are identified in table 1.

Two sets of photos were taken on each site. The first set was taken in March 1987, before leaf-flush. The second set was taken in late May 1987, under full canopy. These two sets represented winter and summer conditions. View locations used in March were marked by flagging and used again in the May photography.

Table 1.—SBE study sites, owner and residual basal area.

Forester-assisted		Nonassisted	
Site	BA	Site	BA
III-A	84	I-B	87
II-A	79	II-B	75
I-A	65	III-B	73

Within each 20-acre study area, three different photography locations were utilized. Three views were sampled according to random azimuth orientation. Each view was replicated three times by taking three identical exposures from a tripod. This was done to avoid reduction in visual quality usually associated with the copying process of color slides. A Minolta XD-11 camera with a 28-mm lens was utilized; film used was Kodachrome 64.

The winter and summer slide sets each included 54 slides—six areas, three views of each area, each view repeated three times. The two sets of 54 slides were randomly loaded into separate slide trays for later use.

Viewer Interviews

Respondents utilized in the analysis of forest aesthetics came from two populations: (1) faculty and students in forestry at Southern Illinois University and (2) members of organizations with an interest in forestry. A total of 69 respondents were included in the study. Distribution of respondents is shown in table 2.

Each respondent was supplied with an answer sheet to record his or her evaluation. The slides were shown at 8-second intervals using the projector's automatic timing device. Each respondent was asked to record his/her score for each view using the following scale: 0—least scenic, 9—most scenic. No pretest information was given to prevent bias.

Analysis

Since each observer will have his or her own evaluation scale, the results must be standardized for comparison. This is accomplished by converting all the individual observer's rat-

Table 2.—Sample size of respondents by group.

Group	N
Illinois Tree Farm Committee	4
Tree committee	20
Illinois Wood Products Association	12
SIU forestry students	30
SIU forestry faculty	3
Total	69

ings to standard (z) scores by the following formula so that the distribution of the transformed score would have a mean of 50 and a standard deviation of 10:

$$z_{ij} = \frac{R_{ij} - \overline{R}_j}{s_j} \times 10 + 50$$

where

z_{ij} = standardized (z) score for the ith rating of observer j;
$\overline{R}_j$ = mean of all ratings in z sets of observer j;
R_{ij} = ith rating of observer j on the ith slide; and
s_j = standard deviation of all ratings in z sets of observer j.

Therefore, arbitrary differences between observers in how they use a rating scale, both in terms of tendencies to use only the high or low end of the scale and differences in the extent or range of the scale used, would be eliminated by the z-transformation. Also, results of ranking stands in different personal scales (such as 5-point vs. 7-point) could be directly compared (Daniel and Boster 1976). All responses of the 69 observers in the study were, thus, converted to z-scores and reported here as SBE scores. A mean SBE score from 9 slides from each site was computed for each observer for each of the six study sites. These means were used by analysis of variance to determine if any significant differences existed among the harvested sites. The SAS statistical software package in SIU's IBM 370 mainframe computer was utilized to analyze the scores.

Findings

SBE scores were computed for each of the six areas for both summer and winter. Following are the results presented by season.

Summer

The mean SBE scores for the summer views are presented in table 3. Tract I-A was considered by viewers as the most scenic; Tract I-B the least scenic. These results are of interest as Tract I-A was harvested leaving the least residual basal area, 65 square feet, while Tract I-B was harvested leaving the most, 87 square

feet. Both of these relationships were significant (p=0.05). There was no significant difference among the remaining four stands.

Using both the mean SBE scores and the ranks of the scores, observers considered harvests assisted by Division foresters to be more scenic during the summer. In a companion study of the economics of harvests, landowners were generally more satisfied with forester-assisted harvests than those that were nonassisted. This has been accomplished without significant declines in scenic beauty as perceived by others.

The relationship between residual basal area and SBE score in summer is portrayed in figure 1. The relationship is inverse;

Table 3.—Mean SBE scores and rank score, summer views.

Forester-assisted		Nonassisted	
Site	SBE (rank)	Site	SBE (rank)
I-A	131.50 (1)	II-B	72.12 (3)
II-A	95.17 (2)	III-B	65.00 (4)
III-A	64.77 (5)	I-B	27.05 (6)

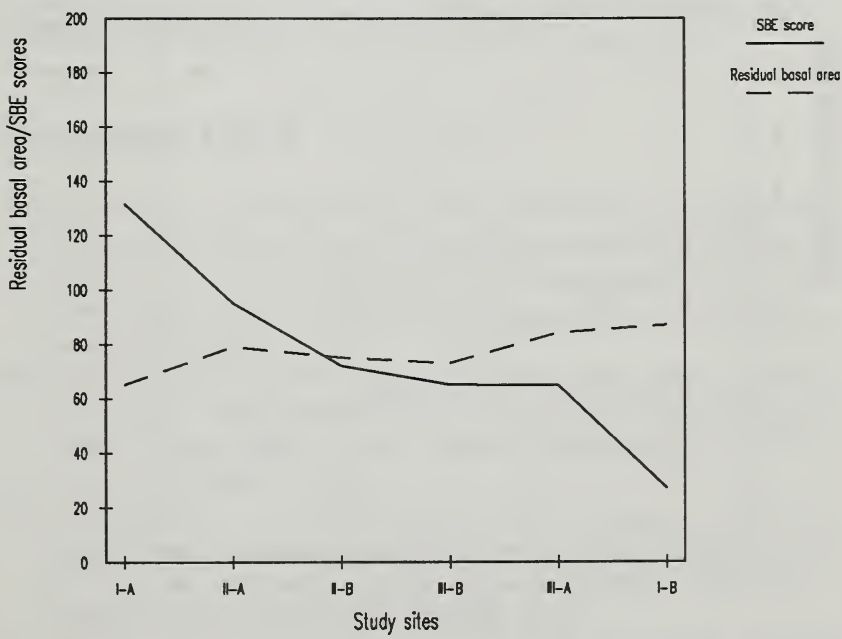

Figure 1.—SBE scores, summer.

apparently viewers prefer a more open stand or a stand in which damage to the original stand is minimal.

Winter

The mean SBE scores for the winter scenes are presented in table 4. For views in winter, observers were mostly indifferent as to the perception of scenic beauty of forester-assisted harvests as compared to nonassisted harvests. Statistically, the scores fall in three overlapping groups: Tracts II-B, III-A, and III-B were significantly more scenic than the others, but no significant relationship existed among these three tracts (p =

Table 4.—SBE scores and rank score, winter views.

Forester-assisted		Nonassisted	
Site	**SBE (rank)**	**Site**	**SBE (rank)**
III-A	43.85 (2)	II-B	57.04 (1)
I-A	26.37 (4)	III-B	37.13 (3)
II-A	23.22 (5)	I-B	1.65 (6)

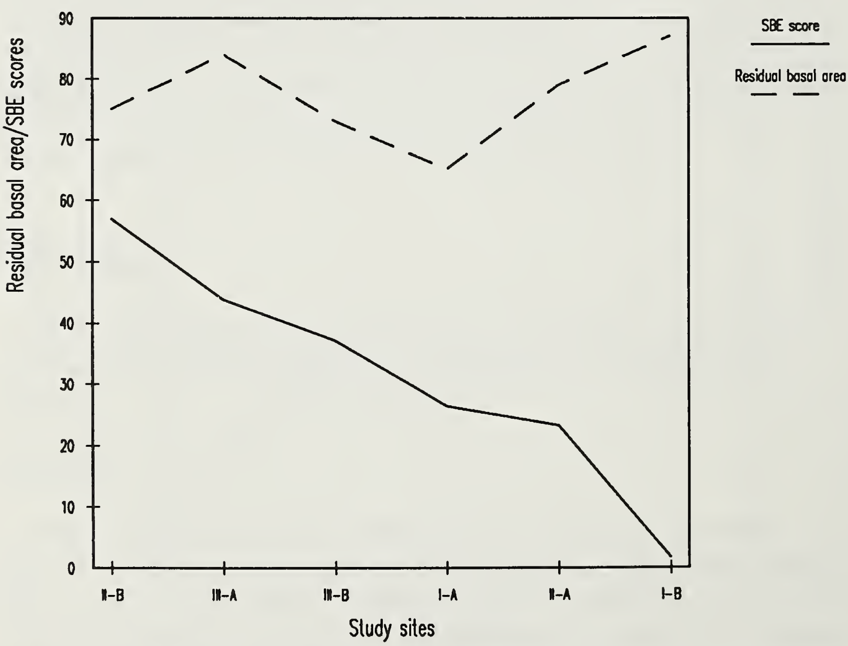

Figure 2.—SBE scores, winter.

0.05); Tracts III-A, III-B, I-A, and II-A were the middle group with no significant difference among them; finally, Tracts II-A and I-B were considered the least scenic group.

The relationship between residual basal area and winter SBE scores is shown in figure 2. Again the tract with the largest residual basal area was considered the least scenic. The relationship is otherwise less clear. From field observations, the tracts considered least scenic were also those with the most logging debris present. This material is not readily apparent during summer, but was quite obvious during winter. The substantially higher SBE scores in summer as compared to winter are likely strongly related to the presence of logging debris in winter photos. These relationships will be tested further in a later study.

Conclusion

Forester-assisted harvests are considered more scenic by observers, as measured by summer views. Winter views suggest an indifference by observers of assisted and nonassisted harvests regarding scenic beauty. Winter harvest scenes are substantially less scenic. The presence of logging debris is a major factor. Additional slash control should be considered.

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An Evaluation of Concession Lease for National Forest Recreation Areas in Taiwan

Shaw-Lin Lo and Chien-Shiun Tzeng[1]

Abstract.—The major objectives of national forest recreation areas are leisure, education, natural conservation, and safeguard of amenity. Concession leasing for national forest recreation area is feasible in Taiwan. The results of this study indicate that concession leases are urgently needed. This means that neither the public enterprise system has drawbacks nor misleads itself when its benefits are increasing or costs are decreasing. Lack of consideration of environmental constraints and institutional factors is one of the main reasons.

Because Taiwan has high population density and shortage of amenity resources, it is important that environmental condition be properly maintained through both public policies and incentive programs in the private sectors. Thus, the monetary and nonmonetary benefits can be obtained. The above-mentioned measures should be adopted with coordination among public administrative sectors. With strict constraints, the concession leasing for national forest recreation areas in Taiwan is not feasible.

Introduction

Forest recreation has recently become a national concern because of rapid urbanization, high density population, increasing personal income, and the needs of recreation opportunities, etc. Therefore, the government of Taiwan several years ago launched an enhanced program of outdoor recreation as one part of national policy.

Various levels of government in Taiwan have explored some new programs including the reformation of forest law, setting

[1]*Department of Forestry, National Chung Hsing University, Taichung, Taiwan, ROC.*

up forest management regulations, and establishing administrative provisions for forest recreation areas at the central government level. On the other hand, the provincial government has developed some practical laws.

Of a total forest area of 1.86 million hectares, 1.57 million hectares of forests belong to national forests, and these forests are administered by the Taiwan Forestry Bureau (TFB). A part of them is also controlled under the National Park System and the Education Ministry (e.g., the experimental forests at the university level). Not only are the forest recreation areas distributed scatteredly in the whole island, but the infrastructure and recreational facilities are extremely limited with a high annual growth rate of 18% of recreationists in the whole country. The time factor, the shortage of public investment, and a flat budget become the main problems to be solved in Taiwan, with an astonishing population density of 549 capita per square kilometer. The shortage of public investment can theoretically be overcome by the capital investment from the private sector if a forest recreation policy can offer incentives. However, the objectives of national forest and private enterprises usually conflict. Furthermore, the ownership and the right of occupancy are not the same for a given piece of land in terms of its land use. This paper mainly examines land use with regard to forest recreation area. The study also built up an ex ante evaluation.

Evaluation and Alternative Analysis Procedures

A number of approaches and criteria for evaluation now exist. Evaluating alternatives by financial and nonfinancial analyses approaches can provide some aids for decisionmaking in private investment activities. These approaches require managerial, legal, and social-cultural considerations. A strictly economic approach is insufficient. The managerial evaluation can lead to adequacy and proper allocation of resources. Evaluation of the legality of alternative actions can help determine their institutional feasibility, and the evaluation of social-cultural base and responses can find out why conventional adaption of policies have been made and estimate likely impacts of new policies. If all of these considerations are integrated with

one another or balanced in trade-off processes, the feasible alternatives will take place as shown in figure 1.

Study Area and the Investigation

The questionnaires used in this study were administered in January 1988 using personal interviews. Fourteen developed forest recreation areas (FRA), thirteen undeveloped areas with potentiality, three areas leased and managed by private enterprises, two experimental forests, and several aborginious-cultural parks were investigated, and 32 responses were received. Four categories of questions were included in the questionnaire.

A. Basic description of the recreation area, such as size in hectares, amount of capital investment, kinds of facilities, number of visitors per year, etc.

B. The current type of management and its proposed form.

C. The description of contract leases, length of the contract, calculation of rent, and rent adjustment.

D. Profit and loss accounting of three leased forest recreation areas.

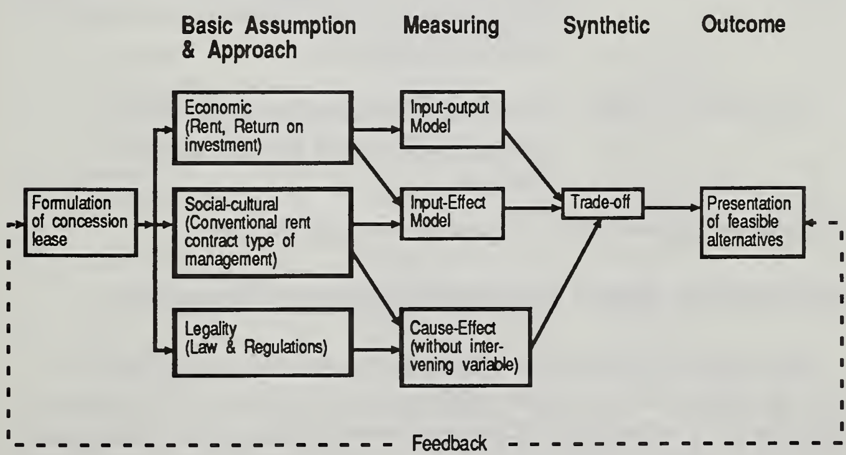

Figure 1.—Evaluating alternative procedures for a concession lease.

Results and Evaluation

The Capital Consumed

According to the first estimation of TFB, capital consumed by national forest recreation areas is devoted to the following activities: 46% of total amount of capital has been allocated for road construction, 23% for the construction of public facilities, and 31% for the establishment of restaurants and lodging facilities (TFB 1987). A similar percentage of capital spending was also found from the field investigation. Some of the highlights from this survey can be summarized as follows.

What are the desirable types of investment?

Four basic types are identified:

Type I (33%):	All public facility constructions should be done by the government. Restaurants and lodging facilities should be invested by private enterprises.
Type II (25%):	All facility construction should be invested by private enterprises.
Type III (12.5%):	All facilities should be constructed by the government, only the management should be taken care of by private enterprises.
Type IV (12.5%):	It should be joint venture of the government and private enterprises.

In addition, some other types are not desirable.

Investment Items Favored by Private Investors

The weighted scores of different recreational facilities are heavily dependent on the willingness of private enterprises or the administrative staff. The total scores of a given facility are shown in table 1.

There is a strong tendency for investment in restaurant and lodging, especially in developed forest recreation areas. In the case of undeveloped forest recreation areas, most investors are interested in providing facilities in their natural forms.

Many more interesting things can be found in table 2 which shows urgency scores for different recreation facilities. This indicates both needs and the shortage of transportation packages in Taiwan, including highways, forest roads, and parking areas. Because of traveling inconvenience, it is necessary to have a further compensation, such as comfortable restaurants, to meet the travel needs. From another point of view, Chinese enjoy being able to eat in a restaurant in these recreation areas.

Contract Period

Three management categories of forest recreation areas are suitable in Taiwan. They are: (1) self-supporting management by the national forest agency, (2) contract with public agency outside the forestry administration, and (3) managed by public agencies outside forestry administration or by private enterprises within specified terms. In consideration of capital budg-

Table 1.—The investment rank and its weighted scores for different recreational facilities.

	Total		Developed FRA		Undeveloped FRA	
Rank order	Facility	Weighted score	Facility	Weighted scores	Facility	Weighted scores
1	restaurant & cafeteria	116	restaurant & cafeteria	93	restaurant & cafeteria	23
2	hotel & lodging	92	hotel & lodging	73	picnic ground	23
3	parking	40	parking	23	campground	21
4	picnic ground	35	villa	18	W.C. & Sanitary	20
5	campground	27	entrance & toll stat	15	hotel & lodging	19
6	villa	27	picnic ground	12	parking	17
7	W.C. & Sanitary	22	cabin	11	road & trail	13

Note: The total weighted scores were measured by the frequencies of response multiplied by its priority number, which is determined by proposed investors or administrative staff. FRA denotes forest recreation areas.

ets, limitations of administration, and laws and regulations, the third category might be the most acceptable and feasible to both the government and private investors.

Provisions of Lease

Before a contract can be signed by the government and the proposed concessionaire a lot of factors need to be settled, such as provisions of limitation, land law, national property law, and regulation of afforestation leasing, etc. Some major issues are discussed below.

Land Law #25: The judgment of any public land for private use is based on releasing its public ownership.

National Property Law #43: The limitation of concession lease for nonpublic use from the fixed asset (estate).

Regulation of Afforestation Leasing: In case of afforestation from any individual or community on a national forest land, the limitation constitutes a maximum period of 9 years, yet it can be allowed to extend several periods.

Table 2.—The urgency scores for different recreation facilities.

	Total		Developed FRA		Undeveloped FRA	
Rank order	**Facility**	**Weighted score**	**Facility**	**Weighted scores**	**Facility**	**Weighted scores**
1	restaurant	116	restaurant	93	restaurant	23
1	restaurant	93	restaurant	60	parking	38
2	parking	82	forest roads	47	campground	34
3	forest roads	62	parking	44	picnic area	33
4	villa	62	villa	42	restaurant	33
5	W.C. & sanitary	53	sewage treatment	32	trail	24
6	sewage treatment	51	W.C. & sanitary	29	W.C. & sanitary	24
7	trail	50	electricity	28	villa	20

Note: The weighted scores were measured by the frequencies of sampling responses multiplied by their urgency priority numbers. These were determined by proposed investors or administrative staff. FRA denotes forest recreation areas.

The recreation license contract period extends in some U.S. cases less than 30 years, and the concession lease of a timber production in Canada is less than 25 years (Michael and Robeson 1977). In addition, some provisions about property insurance and liability insurance are also involved in the context of a contract (USDI 1987).

Return on Capital Investment

An estimate of capital returns for different investment criteria among existing forest recreation areas is shown in table 3. The payback period among three existing recreation areas is varied from 16 to 20 years. Also the range of period based on different discount rates is quite different. In fact, if a private investor has achieved his current income growth rate at a level of 12.93%, then a reasonable contract period extending over 25 years is acceptable.

The Rent Influenced by Law

According to rent theory, a rent is the return from any parcel of land when it is utilized for a certain use. In practice, we classify the rent into the following two categories (Chang 1979):

1. Contract rent or commercial rent, which considers the relationship of one person to another person or persons; and

Table 3.—A comparison of investment return by different criteria.

Name of recreation area	Payback period year	Naive rate of return	Average rate of capital investment[1]	Net present worth r=4.5% year	r=8% year	r=12% year
Wu-lai (North)	16.00	16.25%	1.82%	21[2]	28	46
Loog-Ku (Central)	20.77	4.81%	-0.66%	19	25	39
Sun-Link-Sea (South)	17.81	5.61%	6.87%	19	24	38

[1]*Average annual net profit / 1/2(initial capital investment + salvage value of capital good).*

[2]*This means that under a discounted rate of 4.5%, the NPW is equal to the initial capital invested after 21 years.*

2. Economic rent, which depends on net profit after total revenue less total costs.

The total forest recreation areas of 34,399 hectares located in 53 places are strictly limited, and the land supply for this purpose could not be easily expanded in the future. The contract rent, accordingly, seems to be more significant than that of economic rent in this explanation. Thus, the land investor must pay more attention to other factors (than the targeted use) which may cause the price of the land to increase. On the other hand, if the demand on land resources is strongly identified, then the willingness to pay the rent will be significantly increased. However, the scarcity of recreation areas in Taiwan is a matter of fact that must be faced. The scarcity rent will then be more acceptable (Oyan 1983) (fig. 2).

The contract rent was aimed not only at positive law, but was also determined by the actual effect of multiple decision-makings; therefore, the application of percentage rent is very popular in Taiwan (Fan 1983, Jubenville 1978, Michael and Robeson 1977).

According to the law, forest recreation areas must consist of a managed forest subarea, facility subarea, scenery protection subarea, and forest ecological subarea. Because of the difficulty

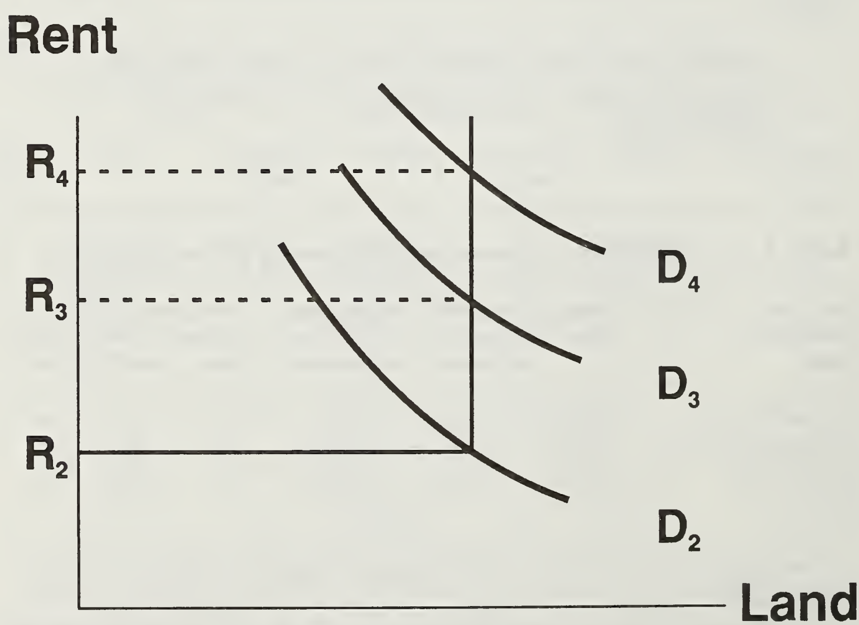

Figure 2.—The basic Model of Scarcity rent.

of determining the market prices for these lands (ad valorem), the forest administrator was unable to solve this problem.

In connection with this discussion of concession leases, some related considerations should be mentioned.

National Property Law

#11: Those who directly use the public property must serve the property as an administrative agency.

#35: Conversion of nonpublic good to the public good must be supervised by the National Property Administrative Bureau (NPAB); meanwhile, the administrative agency will be changed. An example is drawn as follows:

#8: If any forest recreation area was assigned from the National Forest System and also rented by a private investor, that private investor must pay the land tax and additional facility tax, etc.

#43: The rent period of all estates is restricted for: constructed land area < 20 years; nonconstructed land area 6-10 years; and improved facilities < 5 years.

Land Law

#110: The total amount of annual rent should not exceed 8% of the total value of the rented land area.

Conclusions and Suggestions

After a cross analysis, there are three feasible directions for concession leases for national forest recreation areas in Taiwan:

1. Public service as the aim of concession lease.
   - The concession lease will only come with a public agency, like public societies, and local communities. In this case, it is free.

2. Return on investment as the aim of concession lease.

- This is a before-calculation approach and an approach applicable in urban and rural areas. In practice, a combined rent can be calculated as the following equation.

(total land price) times 8% = annual rent and valorem

- Net profit as the basis.

  This formula is applicable for hotel and lodging facilities. The formulas are described as follows:

  net profit (NP) = total revenue - total expenditure

$$\text{rate of net profit (RNP)} = \frac{\text{total revenue} - \text{total expenditure}}{\text{total revenue}}$$

  This is an after-calculation approach. According to income distribution effects and context of income tax law, it is suggested than an increasing acceleration tariff be used, and it should be divided into three classes:

if		RNP < 8%	then	NP. 10% = rent
	8% <	RNP < 18%		NP. 15% = rent
		RNP > 18%		NP. 25% = rent

- A combination of land price and income as the basis.

  This is also an after-calculation approach. Two methods are listed as follows:

  The Minimum Fee (MF) is valid within the first 3 years after the concession lease or when the accounting result is in deficit.

  MF = (market value of land and facilities) times 4%; and

  The Normal Fee (NF) can be used up to the 4th year after the business beginning.

  NF = (gross revenue) times 1%.

The identification of gross revenue by tax payer (enterprise) and the tax acceptor (tax bureau) is usually quite different. It always comes as an obstacle.

3. The division of profits is one other approach. It basically demands a higher technique. The advantage of this technique is its contribution to management stability. But sometimes it might cause some disadvantages, such as excessive profit.

A rational evaluation of a concession lease for national forest land in Taiwan should lead to a compromise for all concerned. However, the legality and social benefits and, above all, the political instrument might be the core issues of national forests. In addition, the concessionaire should make his own economic profit in the mean time to fulfill his social responsibility.

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Application of MGA Methods to Forest Level Decisionmaking

Gene E. Campbell[1] and E. Downey Brill, Jr.[2]

Abstract.—Forest managers and decisionmakers often employ mathematical programming tools to develop land management alternatives. The current USDA Forest Service planning model, called FORPLAN, is one such mathematical programming technique. As analytical aids, these models provide information for improved decisionmaking. However, given stated goals, this information is typically limited in decision-space and, therefore, may be of limited value to forest planners. This is especially true if objectives are poorly defined or unmodeled issues prevent choosing a "mathematical solution" with confidence even if it appears to be the best noninferior solution. In this paper, several Modeling to Generate Alternatives (MGA) methods are adapted to a forest planning example. These methods include the Gibbs inner product minimization and Hop-Skip-Jump (HSJ). The example application illustrates the generation of "maximally" different alternatives in decision-space given that specified target levels are met in objective space. Differences between alternative forest plans generated by these MGA methods are evaluated.

Introduction

Forest planning problems are typically complex and multiobjective, involving tradeoffs among efficiency, equity, environmental protection, administrative requirements, and risk (Campbell and Mendoza 1988). Resolution of these types of problems is far from trivial since substantial quantities of valuable resources are involved and large numbers of people affected. Multiple objective programming (MOP) methods em-

[1]*Department of Forestry, University of Illinois at Urbana-Champaign, Urbana, Illinois.*

[2]*Department of Civil Engineering, North Carolina State University, Raleigh, North Carolina.*

ploying mathematical programming tools are often used to aid public forest planning through development of land management alternatives. An example in the United States is the current USDA Forest Service forest planning (FORPLAN) model.

MOP techniques are designed to solve planning problems involving several criteria or objectives by generating, identifying, or selecting solutions which are nondominated or noninferior. A feasible solution to a planning problem is noninferior if there exists no other feasible solution that will yield an improvement in one objective without causing a degradation in at least one other objective (Cohon 1978). However, the formulation and optimization of a realistic mathematical model are frequently extremely difficult tasks (Kshirsagar and Brill 1984). Empirical problems and unmodeled objectives may prevent analysts and decisionmakers from recommending or choosing a "mathematical solution" with confidence even if it appears to be the best noninferior solution. Thus, because models of complex systems are incomplete, attention should be focused on an optimal decision process rather than on optimal decisions (Harris 1971). For this reason, models should be used to generate different solutions, and these solutions should be examined to study the actual problems of interest. The purpose of this paper is to present a category of methods called modeling to generate alternatives (MGA) and to demonstrate their applicability to forest-level decisionmaking with a hypothetical multiple objective example. Two MGA techniques are discussed and compared.

Conceptual Basis of MGA

Because public-sector planning problems are complex, it is unlikely that complete representation can be achieved by using a mathematical formulation (Brill 1979, Chang et al. 1982). Empirical problems may prevent an exact algorithmic solution, or more seriously, important planning issues may be left out of the multiple objective programming model. These issues may be unknown or unrevealed by decisionmakers (Brill et al. 1982). Other issues or objectives may not be satisfactorily quantified or understood (Chang et al. 1983). In addition, some objectives may be discovered well after the planning process has begun.

The implication of carrying out a partial analysis is that the best planning solution may lie in the inferior region of a multiobjective programming analysis instead of along the noninferior frontier. This conclusion is readily apparent when important planning issues are not included in the mathematical formulation. For example, figure 1 illustrates a best planning solution within the inferior region of a multiobjective programming analysis (Brill 1979). If only one modeled objective is assumed (e.g., maximize objective 1), point A identifies the optimal solution. If a second objective is considered, point B may become the best planning solution yielding a value A' for the first objective. Note, however, that in the context of the incomplete model (i.e., if only objective 1 is considered), A' is an inferior solution. Further, if another objective is introduced, the best planning solution may now be at point C which lies in the inferior region of the two-dimensional mathematical problem.

A further observation is that there are usually numerous mathematical solutions that are nearly the same with respect to modeled objectives but that are drastically different from each other in decision-space (e.g., Brill et al. 1982). As a result, some of these alternative solutions may be much better than

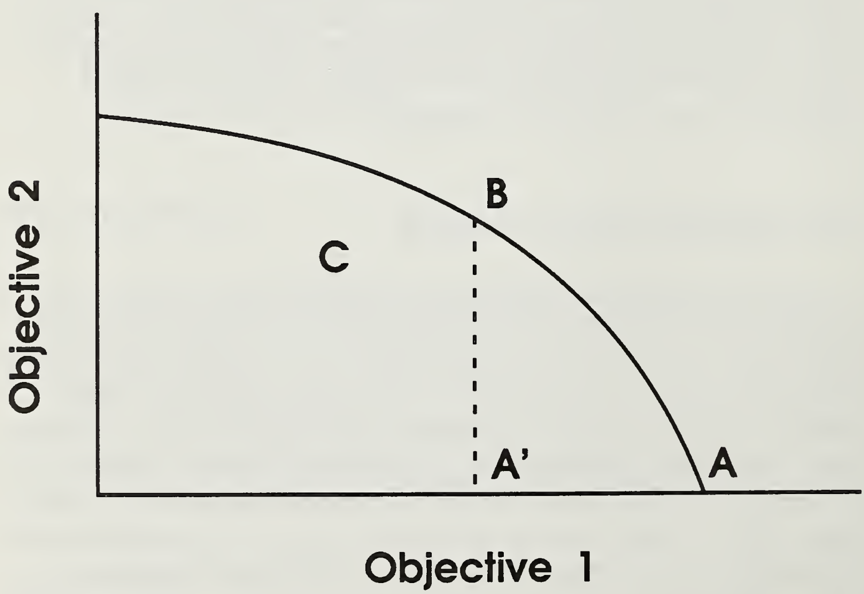

Figure 1.—A "best planning solution" within the inferior region of a multiobjective programming analysis.

others with respect to satisfying unmodeled objectives. Thus, to address this distinction between modeled and unmodeled issues, optimization models should be capable of generating alternative solutions that (1) meet minimal requirements, and (2) are different. This will give analysts and decisionmakers the opportunity to examine a wide range of alternatives in order to gain insight into and understanding of the planning problem, particularly with respect to issues not incorporated in the model.

MGA techniques are intended to generate a small number of alternatives that are as different as possible from each other but feasible given the physical structure of the system and good with respect to target values for well-understood objectives (Hopkins et al. 1982). Two MGA approaches are discussed and compared in this paper: The Hop-Skip-Jump (HSJ) method (Brill et al. 1982), and minimization of the Gibbs inner product (Kshirsagar and Brill 1984).

The HSJ approach uses formal optimization methods to generate alternative solutions that are different. The first step is to use any single or multiple objective programming model to obtain an initial solution. The second step is to obtain an alternative solution by solving the following optimization problem:

$$Min\ p = \sum_{k \varepsilon K} x_k \qquad [1]$$

$$s.t. \quad f_j(\overline{x}) \geq T_j \quad (for\ all\ j) \qquad [2]$$

$$\overline{x}\ \varepsilon\ X \qquad [3]$$

A maximally different solution is obtained by minimizing the sum of the decision variables (x_k) that are nonzero in the initial solution; K is the set of indices of these nonzero variables, $f_j(\overline{x})$ is the jth objective function, T_j is the target specified for the jth modeled objective, and X is the set of feasible solutions based on the "technical" constraints of the model.

The next step is to generate a third alternative that is different from the first two. The same procedure is followed; that is, the minimization of the sum of the decision variables that are nonzero in the previous solutions. The generation of additional alternatives continue until a stopping rule is reached.

In general, there are two stopping criteria for the HSJ procedure:

1. When it is no longer possible for new decision variables to enter the solution because all decision variables are already included in the objective function described in equation [1]. This implies that all decision variables have at one time been a part of a generated alternative solution.

2. When the analyst terminates the procedure after a large number of alternatives have been generated or when the difference between each new alternative and a previous one becomes insignificant.

The second MGA method discussed here is the minimization of the Gibbs inner product (GIP) developed by Kshirsagar and Brill (1984). Conceptually, the Gibbs inner product is analogous to the dot product (or Euclidean inner product) of ordinary vector algebra. It can be interpreted as the product of the orthogonal (perpendicular) projection of U onto V and the norm (length) of V. This technique is similar to HSJ in that it uses the constraints of the original mathematical formulation to ensure that the solution obtained is feasible. Targets are also set for the planning objectives included in the model. The procedure differs from HSJ by minimizing the following objective function:

$$Min\ z = U \cdot (V_1 + V_2 + \cdots + V_\alpha) = U \cdot V_1 + U \cdot V_2 + \cdots + U \cdot V_\alpha \quad [4]$$

where U is the new decision vector being generated and V_1, $V_2, \ldots, V_\alpha$ are the known (prior) decision vectors. This minimization causes decision variables that were previously zero or at a low level to tend to increase in value and the high valued variables to tend to decrease in value (Kshirsagar and Brill 1984).

Put simply, the objective is to minimize a function equal to the weighted sum of nonzero decision variables from prior solutions (Kshirsagar 1983). The weight for a given variable equals the sum of its values from all prior solutions. In this way, a feasible, and good, solution is generated efficiently. Different solutions may be generated by continuing to minimize newly created objective functions.

The specific formulation used follows. The first objective function (equation [5]) is formed by the nonzero decision variables (x_k) from the initial solution. These variables are then assigned a weight (w_k) equal to their value in the initial solution:

$$Min\ z = \sum_{k \varepsilon K} w_k x_k \qquad [5]$$

$$s.t. \quad g_i(X) \leq b_i \quad (for\ all\ i) \qquad [6]$$

$$f_j(X) \geq T_j \quad (for\ all\ j) \qquad [7]$$

where K is the set of indices of these nonzero decision variables, $g_i(X) \leq b_i$ is the ith constraint in the original model, $f_j(X)$ is the jth planning objective in the original model, and T_j is the target specified for the jth objective to ensure that the solution obtained is good. The second and succeeding objective functions are found by summing the nonzero decision variables, including their previous values, from all prior solutions. The new solutions obtained are expected to be different from each other with respect to the values of the decision variables and possibly with respect to important issues not included in the model.

Example Problem

A problem adapted from Bell (1976) is used to illustrate the applicability of MGA to forest-level decisionmaking. Five objectives are considered: (1) timber, (2) forage, (3) developed recreation, (4) dispersed recreation, and (5) water production. There are three management units with a total area of 18,210 hectares. The planning problem involves the allocation of forest lands within these management units to the five land uses noted above such that total forest benefits are maximized. Table 1 presents the objectives and system constraints included in the forest planning model.

To determine the maximum feasible values for the five planning objectives, each was optimized independently. The results are given below:

Objectives	**Value per year**
Timber	19,615 cubic meters
Forage	4,082,328 kilograms
Developed recreation	16,099,670 visitor-days
Dispersed recreation	147,450 visitor-days
Water production	34,292 1000 cubic meters

Table 1.—Planning unit objectives, per hectare output per year, and constraint matrix for three management units.

	Management Unit A					Management Unit B			Management Unit C					
	Management activity by primary objective													
	Disp Rec. (1)	Forage (2)	Wild. (3)	No Mgmt. (4)	Devel. Rec. (5)	Max. Timber (6)	Disp. Rec. (7)	Forage (8)	Max. Timber (9)	Devel. Rec. (10)	Mod. Timber Mgmt. (11)	Disp. Rec. (12)	Forage (13)	rhs
Objectives														
							Units per hectare							
1. Timber (cu. meters)						1.83	1.59	1.74	1.09		0.74	0.88	1.03	
2. Forage (kilograms)	112.09	168.13	112.09	112.09	33.62	140.11	134.50	156.92	280.21		274.61	280.21	308.23	
3. Developed Recreation (rec. visitor-days)					4,942					3,707				
4. Dispersed Recreation (rec. visitor-days)	4.94	1.24	0.25	0.25		1.24	1.85	1.24	12.36		14.83	13.59	1.24	
5. Water (1,000 cu. meters)	2.44	2.44	2.44	2.44	2.74	3.05	3.05	3.05	0.60	0.60	0.60	0.60	0.60	
Constraints														
6. Sediment (tonnes)	8.96	8.96	6.72	6.72	8.96	11.21	10.09	11.21	15.69	4.48	13.45	13.45	13.45	≤213,188
7. Maximum Wilderness (hectares)			1											≤1,619
8. Minimum Wilderness (hectares)			1											≥809
9. Unit A (hectares)	1	1	1	1	1									=4,047
10. Unit B (hectares)						1	1	1						=6,070
11. Unit C (hectares)									1	1	1	1	1	=8,094
12. Recreation Zone (hectares)										-121	1			≥ 0

Note: Disp. Rec. = dispersed recreation; Wild. = wilderness; Mgmt. = management; Devel. Rec. = developed recreation; Max. = maximum; Mod. = modified; rhs = right-hand-side; cu. = cubic; rec. = recreation.

For illustrative purposes, assume that dispersed recreation is an unmodeled objective and that the initial planning solution is determined by maximizing timber production subject to meeting specified target levels for the remaining modeled objectives. The target levels are set equal to 75% of the individual maximizations. The results of this incomplete MOP analysis are:

Modeled objectives	**Value per year**
Timber	19,438 cubic meters
Forage	3,562,203 kilograms
Developed recreation	**12,074,752 visitor-days**
Water production	34,050 1000 cubic meters
Unmodeled objective	Value per year
Dispersed recreation	35,728 visitor-days

The first step in MGA is to use this initial solution to generate other alternatives which are different in decision-space but good with respect to modeled objectives. HSJ will be demonstrated first. The second step is to minimize the sum of the decision variables that are nonzero in the initial solution (i.e., min $p = x_3+x_4+x_5+x_6+x_9+x_{13}$). Minimal target levels for the modeled objectives (which are at their limits in the initial solution) are set at 17,698 cubic meters for timber and 10,000,000 visitor-days for developed recreation. These target levels are considered to be satisfactory. The objective function values generated by this minimization are given in the HSJ1 row in table 2.

Table 2.—Summary of objective function values generated by Hop-Skip-Jump (HSJ).

Objectives	**Modeled**				**Unmodeled**
Solution	**Timber** *(m^3)*	**Forage** *(kg)*	**Developed recreation** *(RVDs)*	**Water production** *(1000 m^3)*	**Dispersed recreation** *(RVDs)*
Initial	19,438	3,562,203	12,074,752	34,050	35,728
HSJ1	17,698	3,515,338	10,000,000	33,922	123,700
HSJ2	17,698	3,500,029	10,000,000	33,922	92,512
HSJ3	17,698	3,378,250	10,000,000	33,916	122,662
HSJ4	17,698	3,378,250	10,000,000	33,916	122,662

m^3 = cubic meters.
kg = kilograms.
RVDs = recreation visitor-days.

The next step is to generate a third alternative by minimizing the sum of the nonzero or basic decision variables identified in HSJ1 and the initial solution (i.e., min $p = x_1+x_3+x_4+x_5+x_6+x_8+x_9+x_{12}+x_{13}$). HSJ2 is the new solution. This process was repeated until no new variables entered the solution. In table 2, it is interesting to note that alternative HSJ1 is clearly inferior (compared to the initial solution) based on the four modeled objectives. However, when the unmodeled objective is included, HSJ1 becomes nondominated or noninferior. This is because the value for dispersed recreation generated by HSJ1 is greater than its value in the initial solution.

Minimization of the Gibbs inner product, like HSJ, begins with an initial solution generated from the original MOP formulation. However, the second step differs by minimizing an objective function that is equal to the weighted sum of the nonzero decision variables in the initial solution (i.e., min $z = 809x_3+794x_4+2{,}443x_5+6{,}070x_6+1{,}604x_9+_{6}{,}490x13$). This step would be identical to the corresponding HSJ step if all the weights were equal to one. The modeled and unmodeled objectives, and minimal target levels, are the same as in the HSJ illustration. The objective function values generated by this minimization are displayed in the GIP1 row of table 3.

Five additional solutions were generated using the Gibbs inner product minimization technique, each solution a result of minimizing the weighted sum of prior decision variables. For example, the objective function used to generate solution GIP2 was: min $z = 1{,}214x_2+1{,}618x_3+794x_4+4{,}466x_5+6{,}070x_6+6{,}070x_8+1{,}604x_9+8{,}094x_{12}+6{,}490x_{13}$. As seen in table 3, the same type of relationship between modeled and unmodeled objectives exists as with HSJ. That is, an alternative can be clearly inferior with respect to modeled objectives, but noninferior when unmodeled issues are considered. In this example, solution GIP6 is dominated by the initial solution in the incomplete MOP analysis. For the full model, however, GIP6 is definitely nondominated or noninferior since it provides the greatest level of dispersed recreation.

Comparison of Differences

Two measures of difference are used to compare alternatives generated by the two MGA approaches (for earlier work on comparing alternative solutions see Brill et al. 1982). The first

measure is the variation among solutions in the number and type of land uses, including the number of hectares allocated to each use. Table 4 shows the variation in decision-space for the initial, HSJ, and GIP solution alternatives. It can be seen that a significant amount of input variation is possible without causing modeled outputs to become unsatisfactory. For example, HSJ1 has eliminated four of the six land uses found in the initial solution while adding three new ones. In addition, the number of hectares allocated to developed recreation in Management Unit A is changed from 2,443 to 2,023. Only one land use remains unchanged. Finally, there are only two nonzero variables that are common between the initial solution and HSJ1. The remaining HSJ and GIP solutions show other alternatives that are "different" in decision-space, but satisfactory in objective-space.

The second measure of difference, variation in the value of the unmodeled dispersed recreation objective, is presented in figure 2 and table 5. It is shown that a substantial amount of variation in the unmodeled objective exists among alternative solutions. The value of the dispersed recreation objective ranges from 92,512 to 123,700 for the HSJ alternatives, and from 41,050 to 122,751 for the GIP alternatives (table 5). Note that the range in value is significantly greater if the value of dispersed recreation from the initial solution is considered. Ini-

Table 3.—Summary of objective function values generated by minimization of the Gibbs inner product (GIP).

Objectives	Modeled				Unmodeled
Solution	Timber (m^3)	Forage (kg)	Developed recreation (RVDs)	Water production (1000 m^3)	Dispersed recreation (RVDs)
Initial	19,438	3,562,203	12,074,752	34,050	35,728
GIP1	17,698	3,583,377	10,000,000	33,922	119,200
GIP2	17,698	3,385,470	10,000,000	33,920	109,091
GIP3	17,698	3,418,197	10,000,000	33,916	111,322
GIP4	17,698	3,129,785	10,000,000	32,935	89,200
GIP5	17,698	3,571,598	10,000,000	33,920	41,050
GIP6	17,698	3,462,864	10,000,000	33,919	122,751

m^3 = cubic meters.
kg = kilograms.
RVDs = recreation visitor-days.

Table 4.—Land use allocations for various HSJ and GIP solutions.

	Management Unit A					Management Unit B				Management Unit C				
	Management activity by primary objective													
Solutions	Disp Rec. (1)	Forage (2)	Wild. (3)	No Mgmt. (4)	Devel. Rec. (5)	Max. Timber (6)	Disp. Rec. (7)	Forage (8)	Max. Timber (9)	Devel. Rec. (10)	Mod. Timber Mgmt. (11)	Disp. Rec. (12)	Forage (13)	Number of new basic var.
						Hectares								
1. Initial			809	794	2,443	6,070			1,604				6,490	6
2. HSJ1	1,214		809		2,023			6,070				8,094		3
3. HSJ2		1,214	809		2,023		6,070		3,844		1,973		2,277	3
4. HSJ3		55	1,618	365	2,009	6,070			2,063	20	6,010			1
5. HSJ4		55	1,618	365	2,009	6,070			2,063	20	6,010			0
6. GIP1		1,214	809		2,023			6,070				8,094		3
7. GIP2			809	1,220	2,018		6,070		5,094	7	2,259		733	3
8. GIP3	1,228		809		2,009	6,070			886	19	5,719		1,470	1
9. GIP4		1,214	809		2,023			6,070	6,476			1,618		0
10. GIP5	1,217		809		2,021		6,070			3	1,000		7,090	0
11. GIP6		1,221	809		2,016	6,070				10	2,976	5,108		0

Note:Disp. Rec. = dispersed recreation; Wild. = wilderness; Mgmt. = management; Devel. Rec. = developed recreation; Max. = maximum; Mod. = modified; rhs = right-hand-side; cu. = cubic; rec. = recreation.

tially, the pattern of change is similar for both HSJ and the Gibbs inner product minimization technique. However, as more solutions are generated, the more divergent the two approaches become. The main reason for this divergence is because the performance of the GIP method does not deteriorate as more and more alternatives are generated (Kshirsagar 1983).

Discussion

Forest planning problems are complex and difficult to represent completely in mathematical form. Empirical problems and unmodeled issues may place the best planning solution in

Table 5.—Dispersed recreation objective function values by MGA solution set.

Solution set	Low	High	Range	Percent coverage of possible range
HSJ	92,512	123,700	31,188	21.15
GIP	41,050	122,751	81,701	55.41

HSJ = Hop-Skip-Jump.
GIP = Gibbs inner product minimization.

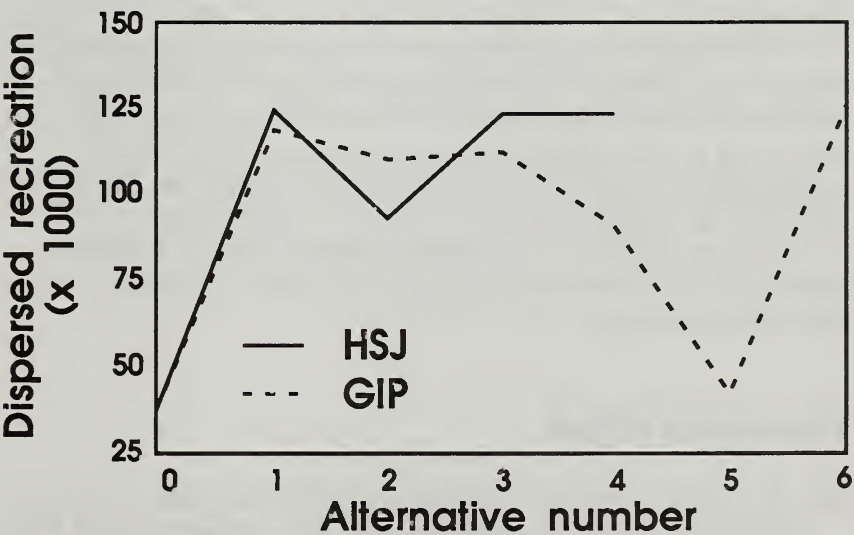

Figure 2.—Dispersed recreation objective function values for alternatives generated by the HSJ and GIP methods.

the inferior region of an "incomplete" multiobjective programming analysis. Modeling to generate alternatives (MGA) techniques recognize these problems through the systematic generation and exploration of alternative solutions in decision-space as well as objective-space. Two criteria are established: (1) that minimal requirements or satisfactory target levels are met; and (2) that alternative solutions are different.

The first criterion is easily met given that these requirements are specified as model constraints. The second criterion is met by formulating a new objective function. In Hop-Skip-Jump (HSJ), the sum of the nonzero decision variables in the final solution of the incomplete model is minimized to find a maximally different alternative solution. For the Gibbs inner product minimization method, a weighted sum of nonzero decision variables from prior solutions is used as the objective function to be minimized. In general, both MGA approaches give similar results, especially if the ratio of nonzero decision variables in any feasible solution to the total number available is small, or if the assigned weights used in GIP are close to being equal. Both may aid the forest planning process by allowing decisionmakers to evaluate alternatives with respect to unmodeled concerns as well as modeled objectives.

MGA methods also are well suited for incorporating nontimber values explicitly into the decisionmaking process. Through the generation of "maximally" different alternatives, decisionmakers will be able to evaluate both modeled and unmodeled issues in an efficient and straightforward manner. As has been illustrated, satisfactory target levels for modeled objectives can be met by a wide range of alternative inputs while allowing unmodeled objectives to vary greatly in magnitude. The significance of this observation is that the opportunity cost of providing nontimber outputs (e.g., forest recreation) may be much less than estimated through adherence to traditional optimization models.

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Rocky Mountains

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